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Of Counsel:
Richard Lowerre

September 21, 2016

Ron Curry
United States Environmental Protection Agency
Region 6
1445 Ross Avenue, Suite 1200
Dallas, Texas 75202

Re: Application of the City of Dripping Springs for TPDES Permit No. WQ0014488003, TX 0136778.

Dear Mr. Curry:

On behalf of Protect Our Water (POW), I am writing to ask that the United States Environmental Protection Agency review Draft TPDES Permit No. WQ0014488003 (the "Draft Permit"),[1] which involves the discharge of 995,000 gpd of domestic wastewater into Walnut Springs Creek, shortly upstream of Onion Creek in Hays County. POW was formed by community members in the Dripping Springs area in order to protect and preserve local creeks and wells, including Onion Creek and the aquifers it recharges. POW includes several landowners with property adjacent to Onion Creek and downstream of the discharge proposed for authorization in the Draft Permit. Through advocacy, education, and – if necessary – litigation, POW seeks to protect the existing pristine nature of surface water in Onion Creek and its tributaries as well as the ground water recharged from these bodies from deterioration due to the release of treated sewage and other contaminants into its waters.

By this permit, TCEQ intends to authorize the discharge of significant quantities of nutrients into a clear hill country stream. This proposed discharge would lower the water quality of the receiving high-quality waters, and thus a full Tier 2 review should be required to evaluate whether the lowering of water quality is necessary for important economic or social development. TCEQ has neglected to perform such a review. Since obtaining delegated authority over NPDES permitting in 1998, Texas has never found that any regulatory action would cause a greater than *de minimis* impact on water quality, and this case exemplifies the potential damage that can result from this systematic failure. Furthermore, available information indicates that the discharge will fail to maintain and protect existing and attainable uses of the

[1] The Notice of Receipt of Application and Intent to Obtain Permit" was published on December 24, 2015. While the technical review is complete and the draft permit has been written by the TCEQ and provided to the applicant, the "Notice of Application and Preliminary Decision" has not been published to date but is expected to be published any day.

receiving waters, and issuance of the permit would thereby violate the requirements of a Tier 1 review.

For these reasons, POW petitions the EPA to review this draft permit. Upon review, POW petitions the EPA to submit specific objections to the TCEQ regarding the draft permit. If TCEQ fails to satisfy such objections, then POW petitions the EPA itself to exercise jurisdiction over the processing of the permit application.[2]

I. A full Tier 2 review should be required prior to issuance of TPDES Permit No. WQ0014488003.

In its current form, the Draft Permit would authorize the City of Dripping Springs to discharge 995,000 gallons per day (gpd) of domestic wastewater into Walnut Creek, shortly upstream of Onion Creek in Hays County, Texas. This discharge would be subject to effluent limits of 5 mg/L $CBOD_5$, 1.2 mg/L NH_3-N, 6.0 mg/L DO, and 0.15 mg/L total Phosphorus. Put another way, the draft permit would authorize the discharge of more than 450 pounds per year of phosphorus into a currently phosphorus-limited clear Hill Country stream, with a current estimated annual load of about a pound of total phosphorus each year. Under terms of the proposed permit, the proportional increase in nutrient nitrogen would be even larger than phosphorus. Currently, the stream has a total nitrogen load of 37 pounds per year, while the proposed discharge would cause an annual loading of 88,000 pounds of total nitrogen.

Historic and recent water quality monitoring indicates that the receiving waters for this discharge are of excellent quality with respect to nutrients, dissolved oxygen and the absence of algae. The immediate receiving water for the discharge is intermittent, but at a short distance of less than 1/2 mile downstream of the discharge the effluent will flow into a perennial portion of Onion Creek. Water quality monitoring in this location in 1981 indicated a Chlorophyll-*a* concentration of 0.3 µg/L, an orthophosphate phosphorus concentration of less than the detection limit (<0.01 mg/L), an average dissolved oxygen concentration of 8.1 mg/L, a total nitrogen concentration of 0.36 mg/L.[3] More recent water quality monitoring demonstrates that the quality of the receiving waters has remained high. Specifically, monitoring by the City of Austin has measured orthophosphorus as P in concentrations normally in the range of 0.01 mg/L to 0.02 mg/L,[4] and a dissolved oxygen concentration of 9.62 mg/L.[5]

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[2] Although this draft permit purports to authorize a domestic discharge of less than 1 mgd, issuance of the draft permit would violate applicable provisions of federal and state statutes and regulations for the reasons discussed herein. Thus, POW petitions EPA to exercise its authority under the September 14, 1998 Memorandum of Agreement between the United States Environmental Protection Agency and the Texas Natural Resource Conservation Commission dated September 14, 1998 (the MOA) at Section IV.8, which provides that EPA may terminate a waiver of review of permit actions at any time by notice to TCEQ (Which has assumed the duties and responsibilities previously held by TNRCC) if because of possible issuance of a draft permit that would violate applicable provisions of federal and state statutes and regulations. Upon termination of this waiver, POW petitions EPA exercise its authority of review pursuant to Sections III.B.4 and IV.C of the MOA. Upon review, POW petitions the EPA to exercise its authority to object to the draft permit pursuant to Section IV.D.4 of the MOA. If TCEQ fails to correct the deficiencies in the draft permit as described herein, POW petitions the EPA to exercise its authority under Section IV.D.5 of the MOA to assume direct jurisdiction over the permit application.

[3] Sampling performed at TCEQ Water Quality Monitoring Station 12453 at Onion Creek at Highway 12 on May 20, 1981.

[4] City of Austin Water Quality Sampling at Site # 1116 at Onion Creek at Highway 12.

[5] City of Austin Water Quality Sampling at Site # 1116 at Onion Creek at Highway 12.

On March 12, 2014, the City of Austin analyzed nutrients and benthic algae in 15 samples from Onion Creek near and downstream from the proposed wastewater effluent outfall. Chlorophyll-a in these samples ranged from less than the detection limit to 6.53 mg/L, with a mean of 0.19 mg/L.

All results in the 15 samples for phosphorus were less than detection limits. Measured total nitrogen concentrations ranged from 0.13 to 0.41 mg/L. The measured concentrations and an assumed critical condition flow rate of 0.1 cubic feet per second translate to existing nutrient loads in Onion Creek at critical conditions of one pound of total phosphorus and 37 pounds of total nitrogen. The proposed effluent discharge would increase these loads by factors of 450 for phosphorus and 2,400 for nitrogen.

These data are summarized in Table 1. A comparison with oligotrophic-mesotrophic boundary concentrations[6] indicates that Onion Creek in the vicinity of the proposed effluent discharge has remained within an oligotrophic state for more than 30 years.

Table 1. Onion Creek Water Quality Compared to Oligotrophic – Mesotrophic Boundary

Variable (units)	**Oligotrophic-Mesotrophic Boundary[7]**	**Onion Creek in 1981[8]**	**Onion Creek in 2014[9]**
Sestonic chlorophyll-*a* (mg/L)	10	2.0	0.997
TN (mg/L)	0.7	0.345	0.24
TP (mg/L)	0.025	<0.01	0.01

The current fauna and flora present in the receiving waters of Walnut Creek and Onion Creek reflect this high water quality. Water within the receiving area of Onion Creek is clear, with little algae present.

[6] Dodds, Walter K., John R. Jones, and Eugene B. Welch, Suggested Classification of stream Trophic State: Distributions of Temperate Stream Types by Chlorophyll, Total Nitrogen, and Phosphorus in Water Resources, Volume 32, No. 5, pp. 1455-1462, 1998.
[7] U.S. Environmental Protection Agency, *Nutrient Criteria Technical Guidance Manual: Rivers and Streams*, EPA-822-B-00-002, July 2000, Table 2 on page 27.
[8] TCEQ data from Station 12453, Onion Creek @ FM 12.
[9] Average of 15 samples collected by City of Austin from Onion Creek near and downstream from proposed discharge location on March 12, 2014. One-half detection limit assumed for values measured less than detection limit.

Photograph of Onion Creek Downstream of Discharge Point

POW Member Wading in Clear Onion Creek Shortly Downstream of Discharge

Onion Creek provides high-quality recharge to the Edwards Aquifer, and is a major source of recharge to Barton Springs, which is habitat for federally-listed endangered species: the Barton Springs salamander (*Eurycea sosorum*); and the Austin Blind Salamander (*Eurycea waterlooensis*). Barton Springs is also a critical recreational and economic resource of the City of Austin.

The discharge proposed for authorization by the Draft Permit would degrade the high quality waters of Onion Creek. The City of Austin has utilized the Water Quality Analysis Simulation Program (WASP) to evaluate the impact of the discharge. This modeling focused on the area of Onion Creek shortly downstream of the convergence between Walnut Creek and Onion Creek, and modeled conditions from January 1, 2000 to October 26, 2015. Available data indicates that under baseline conditions the annual mean benthic chlorophyll *a* at this location is always under 25 mg/m^2, and in most years is under 10 mg/m^2.[10] Under these conditions, the Creek would be characterized as oligotrophic, with limited algal growth.[11]

The City modeled the impact of the discharge during this same timeframe. Under discharge conditions, the annual mean benthic chlorophyll *a* concentrations are approximately 50 mg/m^2 from 2001 to 2015.

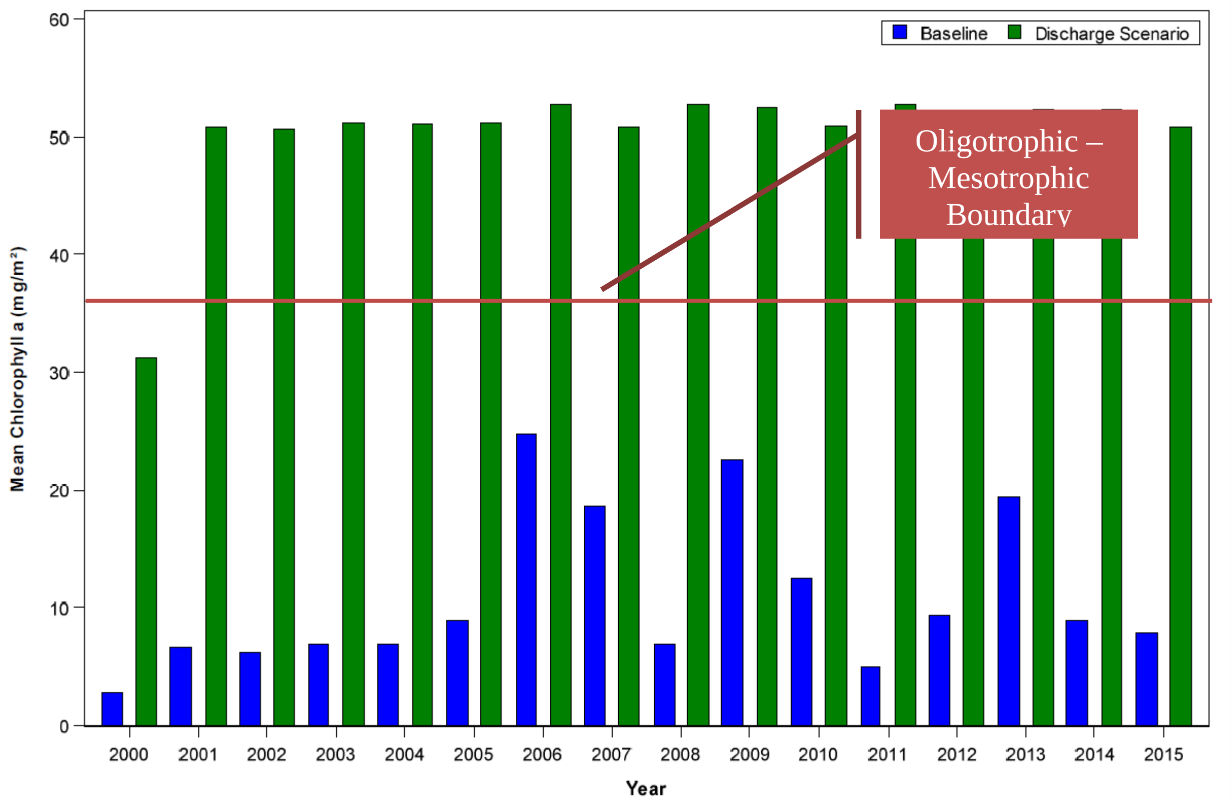

Figure 1: Annual mean benthic chlorophyll *a* (mg/m^2) from modeled data on Onion Creek at a distance of 200 m (656 feet) from where the Dripping Springs WWTP effluent would enter Onion Creek.

The City of Austin also evaluated the spatial extent of water quality impacts of the proposed discharge. In all years modeled, the discharge resulted in mesotrophic conditions within Onion for a distance of at least 8.5 miles downstream of the confluence of the discharge with Onion Creek, and in some cases a distance of more than 12 miles downstream of the confluence point.[12]

Considering the impact which the proposed discharge will have on water quality, the discharge authorized by the Draft Permit should be subject to a Tier 2 review. Texas' Water

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[10] City of Austin, WASP Model Analysis of a City of Dripping Springs Proposed Wastewater Treatment Plant Discharge to Onion Creek, SR-16-05, p. 13 (Attachment A to this letter).
[11] City of Austin, WASP Model Analysis of a City of Dripping Springs Proposed Wastewater Treatment Plant Discharge to Onion Creek, SR-16-05, p. 13, citing Dodds, Walter, Eutrophication and Trophic State in Rivers and Streams, *Limno. Oceanogr.* 51(1, part 2) 2006, 671-680. (Observing an oligotrophic/mesotrophic threshold of 36 mg/m^2 chlorophyll-*a*, which the draft permit would cause to be exceeded in Onion Creek).
[12] Attachment B to this Letter depicts these distances.

Quality Standards provide that "No activities subject to regulatory action that would cause degradation of waters that exceed fishable/swimmable quality are allowed unless it can be shown to the commission's satisfaction that the lowering of water quality is necessary for important economic or social development."[13] As a perennial stream, Onion Creek is presumed to have a high aquatic life use (fishable),[14] and is presumed to be subject to primary contact recreation 1 (swimmable).[15] Thus, a Tier 2 review must be undertaken prior to the authorization of an activity that would cause the degradation of Onion Creek.

Texas' Water Quality Standards contain an exemption to the Tier 2 review that TCEQ has improperly applied in this case. Under the Texas WQS, "degradation" is defined as "a lowering of water quality by more than a de minimis extent, but not to the extent that an existing use is impaired."[16] The TCEQ Water Quality Standards Implementation Team has concluded that "no significant degradation of water quality is expected in Onion Creek, which has been identified as having high aquatic life uses."[17] On this basis, TCEQ has not required that Dripping Springs demonstrate that the discharge is necessary for important economic or social development.

This reasoning is flawed in two respects. First, TCEQ itself has stated only that no *significant* degradation of water quality is expected in Onion Creek. The Texas Water Quality standards require a Tier 2 demonstration of economic or social need so long as any "degradation" of the relevant water will occur. TCEQ has not documented any finding that the discharge will not cause the degradation of Onion Creek. Without this finding, it is improper to issue the permit without first determining that the discharge is necessary for important economic or social development.

Second, it would be unreasonable to find that the discharge will not cause the degradation of water quality in Onion Creek. Any such finding would be contrary to the Texas WQS, as well as Federal law and policy regarding anti-degradation. The Clean Water Act does not contain a "de minimis" exception to the statutory objective of maintaining the chemical, physical, and biological integrity of the Nation's waters.[18] Likewise, EPA's regulations do not contain a "de minimis" exception to the full requirements of a Tier 2 review.[19]

Thus, any such exception must be interpreted and applied narrowly. When reversing EPA's approval of Kenucky's Tier 2 Review process, the Sixth Circuit Court of Appeals affirmed this restriction on the scope of a *de minimis* exemption:

> Under this well-established principle, it is "permissible as an exercise of agency power, inherent in most statutory schemes," to create categorical exemptions "to overlook circumstances that in context may fairly be considered de minimus." *Alabama Power Co. v. Costle, 204 U.S. App. D.C. 51, 636 F.2d 323, 360 (D.C. Cir. 1979).* This authority to create exemptions "is not an ability to depart from the statute, but rather a tool to be used in implementing the legislative design." *Id.* In other words, "this exemption authority is narrow in reach and tightly bounded

[13] 30 TAC § 307.5(b)(2).
[14] 30 TAC § 307.4(h)(3).
[15] 30 TAC § 307.4(j)(2)(A).
[16] 30 TAC § 307.5(b)(2).
[17] TCEQ Interoffice Memorandum From Lili Murphy, Standards Implementation Team to Municipal Permits Team, July 12, 2016.
[18] 33 U.S.C. § 1251(a).
[19] 40 C.F.R. 131.12(a)(2).

> by the need to show that the situation is genuinely de minimus or one of administrative necessity." *Id. at 361*. Accordingly, an agency only has implied authority to create an exemption "when the burdens of regulation yield a gain of trivial or no value." *Greenbaum v. EPA, 370 F.3d 527, 534 (6th Cir. 2004)*[20]

TCEQ has exempted all of its regulatory actions from a Tier 2 review in reliance on the “de minimis” exception contained in the Texas Water Quality Standards, thereby using this exemption as a means to depart from the requirements of the Clean Water Act, while undermining the objectives of that Act. Since obtaining delegated authority over NPDES Permitting in 1998, Texas has never found that any regulatory action would cause a greater than *de minimis* impact on water quality.

The proposed discharge for which Dripping Springs seeks authorization exemplifies the type of circumstance where a full Tier 2 Review is critically important. The proposed permit would authorize a new discharge. The EPA’s Water Quality Standards Handbook provides that activities such as a new discharge are *presumed* to result in a lowering of water quality.[21] There is no indication that such a presumption should not apply in this case. In fact, the best available modeling supports this presumption, by confirming that the addition of new pollutants as a result of the new discharge will result in a lowering of water quality with consequent adverse impacts.

This is also a case where the balancing test required by a full Tier 2 evaluation is warranted. EPA’s Water Quality Standards’ Handbook provides that the lowering of water quality should only be allowed “in a few extraordinary circumstances where the economic and social need for the activity clearly outweighs the benefit of maintaining water quality above that required for ‘fishable/swimmable’ water, and both cannot be achieved.”[22] In this case, the City of Dripping Springs has alternatives to the discharge that could provide the wastewater treatment needs of the area. Specifically, Dripping Springs currently has a state permit for the reuse of wastewater *via* subsurface irrigation.

A full Tier 2 evaluation would properly consider the balance between Dripping Springs’ desire to discharge wastewater into Onion Creek as against the significant interests that rely upon this high-quality water. Onion Creek is a substantial waterbody, and shortly downstream landowners use Onion Creek for recreational purposes.

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[20] *Kentucky Waterways Alliance v. Johnson*, 540 F.3d 466 (6th Cir. 2008).
[21] Environmental Protection Agency, Water Quality Standards Handbook, at 4.5. EPA 823-B-94-005a.
[22] *Id.*

POW Member Wes Pitts and Family Recreating in Onion Creek Downstream of Discharge

Beggs Family Recreating On Onion Creek

Furthermore, Dripping Springs Water Supply Company utilizes groundwater wells near Onion Creek, which are fed by Onion Creek, in order to supply potable water to numerous area residences. Moreover, Onion Creek provides recharge to the Edwards Aquifer, which has been recognized by the EPA as a Sole Source Aquifer. This recharge provides valuable support for endangered species in Barton Springs, and for the recreational uses of Barton Springs.

A gain-loss study was jointly performed by the Barton Springs Edwards Aquifer Conservation District (BSEACD), Hays-Trinity Groundwater Conservation District (HTGCD), the City of Austin, and Blue Creek Consulting, LLC, which included an examination of this portion of Onion Creek.[23] That study noted that Onion Creek is an important link between the Hays-Trinity Aquifer in Central Texas and the Edwards Aquifer.[24] The Study went on to note that This watershed is rapidly being developed and is experiencing significant population growth and land use changes, with several wastewater treatment plants already operating in the watershed with additional treatment plants being planned.[25] With regard to water quality, this Study noted that Nitrate-nitrogen concentrations measured downstream of RR12 in 2014 to 2015 averaged 0.087 mg/L (detection limit of 0.008 mg/L), but that gradual increases in nutrient concentrations are evident and likely due to population growth.[26] This Study also notes that concentrations of nitrate that have increased six to ten times from 1990 to 2008 compared to the

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[23] Hunt., B.B., A.S. Broun, D.A. Wierman, D.A. Johns, and B.A. Smith, In Press, Surface-Water and Groundwater Interactions Along Onion Creek, Central Texas: Gulf Coast Association of Geological Societies Transactions, 66th Annual Convention, September 18-20, 2016, Corpus Christi, Texas. Attachment C to this letter.

[24] *Id.* at 1.

[25] *Id.*

[26] *Id.* at 7. The intersection of RR 12 and Onion Creek is located little more than 1 mile downstream of the proposed discharge.

2008 to 2010 time period in a study that included two sites on Onion Creek.[27] In several areas Onion Creek is a "losing" stream, confirming the potential for contaminants in Onion Creek to impact nearby groundwater wells such as those owned by members of POW.

The purpose of a Tier 2 review is to provide a wholistic consideration of whether degradation of water quality is necessary in light of the impacts of that degradation. In this case, those impacts warrant attention. Furthermore, a proper Tier 2 analysis considers the cumulative impact of discharges in an area. In this case, the extremely high historic quality of the receiving waters, in combination with the significant water quality impacts of the proposed discharge, along with the critical importance of others' reliance on Onion Creek and the availability of alternate treatment options compels the need to perform a full Tier 2 evaluation to determine whether it can be shown that the lowering of water quality as a result of the proposed discharge is *necessary* for important economic or social development as required by 30 TAC § 307.5(b)(2).

II. Issuance of TPDES Permit No. WQ0014488003 would fail to protect existing and attainable uses, in violation of the applicable Tier 1 standards.

A. The Applicant's Modeling of Dissolved Oxygen Impacts, Relied Upon by the TCEQ, Fails to Establish Protection of Aquatic Life Uses in Onion Creek.

The Applicant's own modeling results show that the uses of the impacted streams will not be protected, and due to Applicant's faulty assumption, the true impact of the discharge will be worse than reflected in the Applicant's modeling.

The applicant's own modeling results predict that the discharge will cause a violation of the state water quality standards. The discharge route for the draft permit flows into Onion Creek in Segment 1427 of the Colorado River Basin. This Segment has been designated as subject to high aquatic life use, with a dissolved oxygen criterion of 5.0 mg/L. Modeling performed by the applicant concluded that the dissolved oxygen concentration within this segment will be reduced to a value of 4.87 mg/L.[28] Of course, this concentration is below the required minimum concentration of 5.0 mg/L. Applicant has dismissed this violation with a claim that "TCEQ normally assumes a departure of 0.2 mg/L as compliant."[29] But, the Texas Water Quality Standards contain no such variance, which has the effect of establishing a dissolved oxygen criterion of 4.8 mg/L, instead of the regulatory 5.0 mg/L. Given that the Applicant's own modeling demonstrates a violation of the 5.0 mg/L dissolved oxygen criterion set forth in the State Water Quality Standards, the draft permit fails to protect existing uses in Onion Creek.[30]

To make matters worse, the applicant's modeling is premised on overly-generous assumptions that violate the Memorandum of Agreement between TCEQ and the EPA regarding use of the QUAL-TX model. That Memorandum, finalized April 4, 2001, required the consistent use of certain model input parameters to ensure a high degree of permit limit consistency. Several assumptions utilized by the applicant to characterize the receiving waters deviate from these assumptions.

[27] *Id.*
[28] Technical Memorandum from James Miertschin, PE, PhD and Bruce Wiland, PE to File, 24 November 2015, p. 8.
[29] Technical Memorandum from James Miertschin, PE, PhD and Bruce Wiland, PE to File, 24 November 2015, p. 8.
[30] Attachment D to this letter is a memo from Dr. Lauren Ross, P.E., which also addresses these deficiencies in the dissolved oxygen modeling relied upon by the TCEQ in this matter.

In modeling the dissolved oxygen impact of the discharge, the applicant used assumptions for base flow, sediment oxygen demand (SOD) and chlorophyll-*a* which violate TCEQ's MOA with the EPA. With regard to base flow, TCEQ guidance, and the Memorandum with EPA, provide that a value of 0.0 ft^3/s is to be used for intermittent streams in the absence of site-specific data, while a value of 0.1 ft^3/s is to be used for perennial streams in the absence of site-specific data. In this case, Applicant has admitted that, "there are no data available for calculation of a 7-day 2-year low flow value on upper Onion Creek[,]" Yet, in violation of the MOA, Applicant assumed a base flow of 0.3 cfs to represent the critical low flow in the receiving waters.[31] With regard to Sediment Oxygen Demand (SOD), the MOA requires that a kinetic value of .35 g/m^2-day be used. Yet, Applicant assumed an SOD rate 0.1 g/m^2-day. Finally, the MOA requires that Chlorophyll-*a* should be set to 0.0 µg/L absent site-specific data that can be used to set minimum levels. Yet, Applicant has included a modeling run that assumes a chlorophyll-*a* concentration of 2 µg/L. This modeling run predicted a DO value of 5.0 mg/L, but such an assumption regarding the presence of chlorophyll-*a* is unjustified in this case.

B. The Discharge Will Impair Onion Creek as a Result of Excessive Algae Growth

Under the Tier 1 criteria, nutrients from permitted discharges must not cause excessive growth of aquatic vegetation that impairs an existing, designated, presumed, or attainable use.[32] As noted above, Onion Creek has a presumed high aquatic life use and primary contact recreation 1. Onion Creek is currently used for recreational activities such as swimming, fishing, kayaking and canoeing.

[31] Further downstream of the discharge, in 2015 streamflow values were observed in the range of 0.3 to 0.6 cfs, but these readings in another area of Onion Creek do not justify the assumptions of base flow contrary to the TNRCC-EPA MOA.

[32] 30 TAC § 307.4(e).

Young POW Member Engaging with Wildlife In Onion Creek Downstream of Discharge

As can be seen in the photo above, the current state of Onion Creek downstream of the discharge is characterized by clear, high quality water that creates ideal conditions for aquatic and recreational uses.

The transition of Onion Creek from an oligotrophic to a mesotrophic state will result in the additional growth of algae in the receiving waters. This additional growth will create a nuisance. The presence of long strings of Cladophora algae, well-known to be associated with high-nutrient wastewater effluent discharges, impedes swimming and recreational use. Algae adversely impacts the aesthetic value of the stream, occludes the currently clean river rock, and compromises the clarity of the water. TCEQ's Tier 1 standards also require that surface waters must be maintained in an aesthetically attractive condition, and require that waste discharges must not cause substantial and persistent changes from ambient conditions of turbidity or color.[33] Due to the eutrophication of the receiving waters, issuance of the draft permit would violate both of these Tier 1 standards.

[33] 30 TAC § 307.4(b)(4), 30 TAC § 307.4(b)(5).

III. TCEQ has not performed an adequate review of the impact of the facility on Endangered Species.

As noted, the discharge is upstream of Barton Springs, which provides habitat for the federally-listed endangered Barton Springs salamander (*Eurycea sosorum*) and the Austin Blind Salamander (*Eurycea waterlooensis*). Under such circumstances, the conditions of the permit should be reviewed carefully to avoid an impact on these species. When delegating authority to Texas to administer the NPDES permitting program, EPA stated that it may use its objection authority to address adverse effects of a discharge on endangered species, even if the State permit is not likely to jeopardize the continued existence of a listed species.[34] At 30 TAC Section 307.6(b)(4), the Texas WQS provide that water in the state must be maintained to preclude adverse toxic effects on aquatic life. At the time of delegation, TNRCC asserted that this standard required that Texas impose case-specific conditions in TPDES permits to protect aquatic and aquatic-dependent species (including listed species) from the toxic effects of discharges when Texas' other toxic criteria and implementation procedures provide insufficient protection.[35] EPA has noted that in exercising oversight over the issuance of permits, a failure of the state to adequately protect endangered or threatened species would justify an objection, since such a failure would constitute a violation of this provision of the Texas WQS.[36] The agency went on to say that "EPA intends to consider the needs of listed species in deciding whether to object to a State permit that fails to ensure compliance with State water quality standards[.]"[37]

Contrary to this provision of the Texas Water Quality Standards, and contrary to Texas' representations to the EPA when obtaining delegated permitting authority, the Commissioners of the TCEQ have recently explicitly stated their belief that the TCEQ has no jurisdiction to consider the impacts of a TPDES permit on endangered species, stating:

> Commissioner Baker: There is an issue regarding endangered species that I think is outside of our purview and I think we have understandings in place with US Fish and Wildlife and Texas Parks and Wildlife to handle that and so if there is an issue there, they're going to, as I recall the way the process works, they step in, and that's not necessarily something we would look at.
>
> * * *
>
> Chairman Shaw**:** I think it's appropriate that we, ensure that we, refer issues that are relevant material and by that that we have authority and jurisdiction over it so I share your concern that we not include that item or other items in general that are outside our jurisdiction. I think it's important that we protect the integrity of our process and it would make sense for us to assume authority that we don't, we're not the EPA. Sorry that was a joke. [38]

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[34] 63 Fed. Reg. 51164, 51196 (Sep. 24, 1998)
[35] 63 Fed. Reg. 51164, 51197 (Sep. 24, 1998).
[36] 63 Fed.Reg. 51164, 51198 (Sep. 24, 1998).
[37] *Id*
[38] February 17, 2016 public meeting of the TCEQ.

Clearly, the Commission has abrogated its duty to apply the Texas WQS in a manner that ensures the adequate protection of endangered species. Under such circumstances, it is incumbent upon the EPA to correct this omission in the TCEQ's evaluation,

I. Conclusion

For these reasons, POW petitions the EPA to review draft TPDES Permit No. WQ0014488003. POW further petitions the EPA to object to that permit on grounds including TCEQ's failure to enforce the anti-degradation requirements of the Texas WQS, and TCEQ's failure to adequately protect impacted species, including impacted endangered species.

Please feel free to contact me if you have any questions.

Respectfully submitted,

Eric Allmon

Eric Allmon
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cc:
Richard Hyde, TCEQ Executive Director
Chris Herrington, P.E., City of Austin Watershed Protection Department

Attachment A

City of Austin
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May 12, 2016

Ms. Bridget C. Bohac
Office of the Chief Clerk (MC-105)
Texas Commission on Environmental Quality (TCEQ)
P.O. Box 13087
Austin, TX 78711-3087

RE: Comments on City of Dripping Springs Proposed Permit No. WQ0014488003

Dear Ms. Bohac:

I write to provide the City of Austin's initial comments on the City of Dripping Springs application for a Texas Pollutant Discharge Elimination System Permit (No. WQ0014488003) that would authorize the discharge of treated wastewater at a volume not to exceed 995,000 gallons per day to the Onion Creek Watershed.[1] The City of Austin hopes TCEQ staff will consider and utilize these comments during the technical review of the proposed permit application.

As it concerns this permit application, the City of Austin ("City") is an affected party. The City requests, as an affected party, notice of subsequent correspondence, proceedings, draft permits, or contested case hearings on this permit.

Onion Creek currently exceeds fishable/swimmable quality, and provides significant recharge to the Trinity and Edwards aquifers. One of the City's interests is to prevent degradation of the water quality in Onion Creek, the Trinity Aquifer and the Barton Springs Segment of the Edwards Aquifer. Over the last 18 years, the City purchased or obtained conservation easements for 9,524 acres of Water Quality Protection Lands in the Onion Creek Watershed at a cost of approximately $66 million dollars. These properties have been preserved in perpetuity to protect the integrity of Onion Creek and regional groundwater resources. Additionally, the City is a participant in the Texas Clean Rivers Program and provides water quality monitoring data from Onion Creek to the TCEQ.

[1] The City reserves its right to amend and supplement these comments.

Based on the City's calibrated and validated Water Quality Analysis Simulation Program (WASP) model[2], a new permit authorizing the unconditional discharge of up to 995,000 gallons per day to Onion Creek with a 0.5 mg/L limit on total phosphorus and no limit on total nitrogen will substantially degrade Onion Creek water quality. Specifically, benthic periphyton would degrade from an oligotrophic condition to a mesotrophic condition for 9 to 12 miles of Onion Creek downstream of the proposed effluent outfall. Attached and incorporated, as part of the City's comments, is a report that summarizes the WASP model (based on the discharge as proposed in the City of Dripping Springs' application) and the impacts of the discharge on Onion Creek.

Thank you for your consideration of these comments. If you have questions, please contact me or Chris Herrington at 512-974-2840 or at chris.herrington@austintexas.gov.

Sincerely,

Patricia (Trish) L. Link
Assistant City Attorney
City of Austin Law Department
P.O. Box 1546
Austin, Texas 78767-1546
Telephone: 512-974-2173
Fax: 512-974-6490
Email: patricia.link@austintexas.gov

CC: Chris Herrington, P.E., City of Austin Watershed Protection Department

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[2] A WASP model evaluates the potential water quality impacts from a wastewater discharge.

WASP Model Analysis of a City of Dripping Springs Proposed Wastewater Treatment Plant Discharge to Onion Creek

SR-16-05, April 2016

Aaron Richter, EIT
City of Austin
Watershed Protection Department
Environmental Resource Management Division

Abstract

The Water Quality Analysis Simulation Program (WASP) is a U.S. Environmental Protection Agency program commonly used to model water quality responses including impacts from nutrient enrichment. City of Austin Watershed Protection Department staff have used the program to predict algal growth under low and high nutrient concentrations in Austin streams. In 2015, the City of Dripping Springs submitted an application for a wastewater discharge permit to the Texas Commission on Environmental Quality (TCEQ). The application seeks authorization to discharge 995,000 gallons per day of treated effluent into Onion Creek in the contributing zone of the Barton Springs Segment of the Edwards Aquifer. Included in the application are the following proposed effluent limits: 5 mg/L carbonaceous 5-day biochemical oxygen demand, 2 mg/L ammonia as nitrogen, and 0.5 mg/L total phosphorus as phosphorus. The application did not include a proposed limit for total nitrogen. The City of Austin built and calibrated a WASP model for the section of Onion Creek from immediately upstream of the proposed discharge confluence to the boundary of the Barton Springs Segment of the Edwards Aquifer Recharge Zone (19 miles) to evaluate the potential water quality impact of the proposed discharge permit. The WASP model was calibrated with data collected by the City of Austin from 2014 to 2015. After calibration, a 15 year scenario that did not include any wastewater discharge was run to simulate a baseline benthic chlorophyll a data set. Additionally, a 15 year scenario was run including input conditions for the proposed discharge permit to simulate a discharge benthic chlorophyll a data set. For the baseline scenario the model showed Onion Creek directly downstream of the proposed discharge location in an oligotrophic state each year. However, when the scenario included discharge, Onion Creek's trophic status changed to mesotrophic state from 2001 to 2015. Additionally, the discharge scenario between the years 2001 to 2015 showed Onion Creek remained in the mesotrophic state for approximately 9 to 12 miles downstream of the discharge location depending on the flow of Onion Creek each year.

Introduction

The City of Dripping Springs applied to the Texas Commission on Environmental Quality (TCEQ) for a new Texas Pollutant Discharge Elimination System permit to discharge treated wastewater effluent into the Onion Creek Watershed in the Contributing Zone of the Barton Springs Segment of the Edwards Aquifer. An engineering firm hired by the City of Dripping Springs submitted a Preliminary Engineering Planning Report (PEPR) that proposed 0.5 million gallons per day of effluent from a wastewater treatment plant (WWTP) be directly discharged into a tributary of Onion Creek. The proposed discharge location was approximately 15 miles upstream of the Barton Springs Segment of the Edwards Aquifer Recharge Zone boundary and in an area underlain by the Upper Glen Rose member of the Trinity Aquifer (Johns 2014).

The PEPR indicated that direct discharge can provide an environmentally "good long term solution for effluent disposal from a Regional WWTP in this area…" (CMA Engineering 2013). No data analysis or water quality modeling was provided to support these conclusions. In the permit application to TCEQ, the City of Dripping Springs proposed discharging up to 995,000 gallons per day of effluent into Onion Creek with treatment standards of 5 mg/L carbonaceous 5-day biochemical oxygen demand (BOD), 2 mg/L ammonia as nitrogen, and 0.5 mg/L total phosphorus as phosphorus.

The City of Austin (COA) has an interest in maintaining the water quality of Onion Creek. COA has purchased or obtained conservation easements for 9,524 acres of Water Quality Protection Lands in the Onion Creek Watershed at a cost of approximately $66 million dollars to date in order to protect the integrity of Onion Creek and the Edwards Aquifer.

Surface water in the contributing zone of the Edwards Aquifer, which includes Onion Creek, has previously been shown to be sensitive to nutrient enrichment (Herrington and Scoggins 2006; Herrington 2008a; Herrington 2008b; Mabe 2007; Richter 2010; Turner 2010). In aquatic systems, nutrients such as nitrogen and phosphorus support the growth of algae and aquatic plants. Nutrient enrichment can occur from the increase of either nitrogen or phosphorus to the aquatic system and can cause an increase in algal biomass to the extent that entire reaches of streams show aesthetic degradation (Wharfe et al. 1984, Biggs 1985, Biggs and Price 1987, Welsh et al. 1988), loss of pollution-sensitive invertebrate taxa (Quinn and Hickey 1990), clogging of water intake structures (Biggs 1985), and degradation of dissolved oxygen and pH levels in the water column (Quinn and Gilliland 1989).

Because no data analysis or water quality modeling accompanied the PEPR, the COA constructed a Water Quality Analysis Simulation Program (WASP) model to assess the creek's response, which will demonstrate the potential impacts of nutrient enrichment on the surface water of Onion Creek. Due to the connectivity between Onion Creek and local groundwater resources, impacts to the surface water of Onion Creek can impact local groundwater resources.

WASP Model & Methods

The Water Quality Analysis Simulation Program (WASP) is a program maintained by the US Environmental Protection Agency (US EPA) and is used to "predict the water quality responses to natural phenomena and man-made pollution" (US EPA 1988).

The COA used an 'Advanced Eutrophication' model type in WASPv7.5 to simulate benthic algae biomass in Onion Creek in response to the proposed City of Dripping Springs WWTP discharge. The model used by the COA is consistent with TCEQ analysis (2006) that showed benthic (attached) algal chlorophyll *a* could be a better indicator of nutrient enrichment than water-column chlorophyll *a* in small, fast flowing Texas streams. Flow type in the WASP model was set to 1-D Network Kinematic Wave with a Euler solution technique, which is a typical solution technique for hydrodynamic models (US EPA 2009).

Time functions and parameters included in the model were solar radiation, fraction of daily light, light extinction, ammonia benthic flux, phosphorus benthic flux, and sediment oxygen demand. Average monthly solar radiation and fraction of daily light were calculated from data obtained from the National Climatic Data Center (NOAA Satellite and Information Service). Ammonia benthic flux, phosphorus benthic flux, and sediment oxygen demand were set to 0.015 mg/m^2-day, 0.015 mg/m^2-day, and 1.0 g/m^2-day, respectively, for each WASP segment based on previous COA WASP modeling efforts. Light extinction was calculated and set to 0.813/meter for each WASP segment based on photosynthetic photon flux data collected using a quantum meter at Onion Creek on April 24, 2014.

Initial segmentation of the model was created through the use of the WASP Builder in BASINSv4.1. In order to calibrate the WASP model, the COA collected data at several locations along Onion Creek. The length of several WASP segments was altered so that WASP output better aligned spatially with COA sample locations and the proposed Dripping Springs WWTP discharge (Figure 1, Table 1).

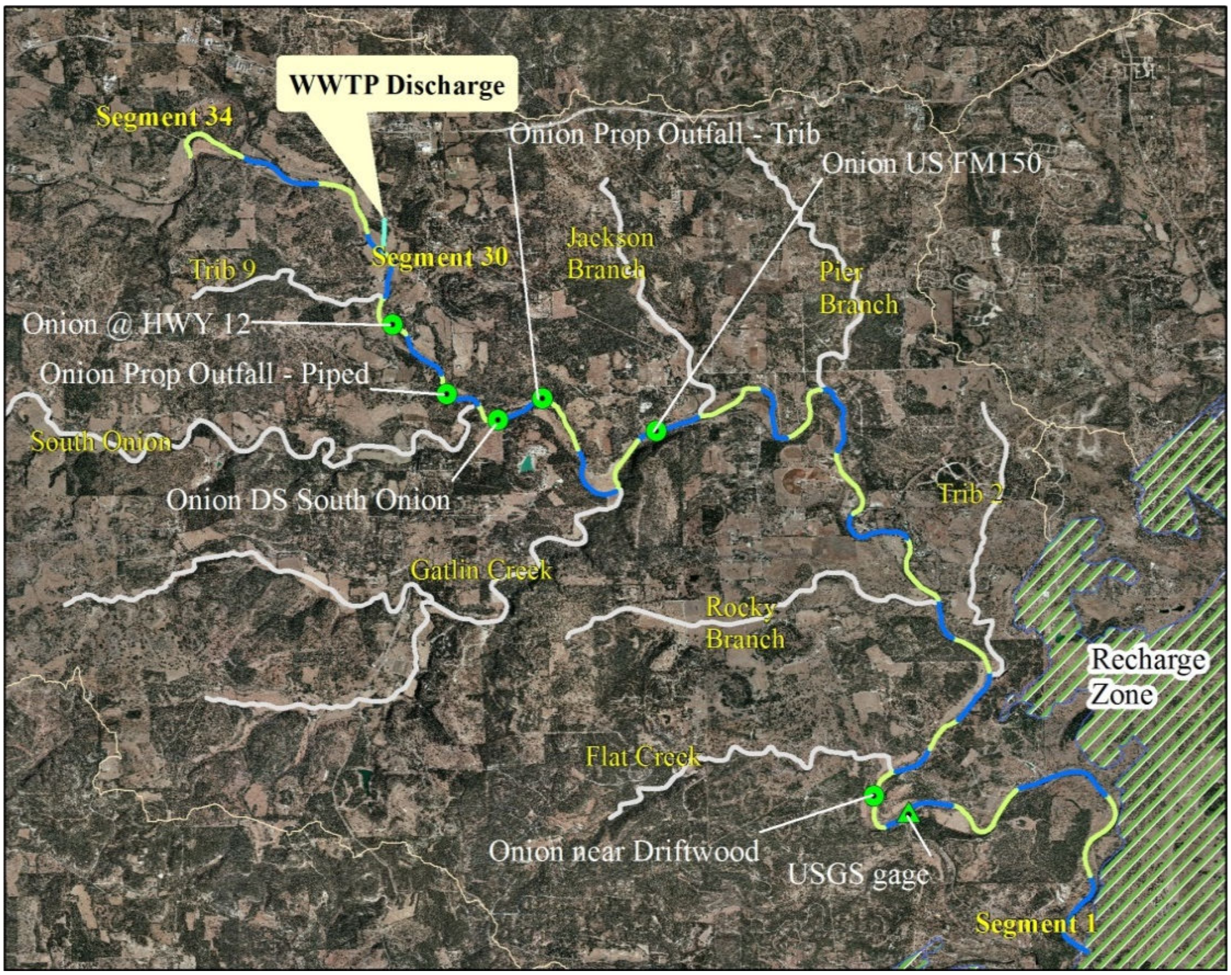

Figure 1: Map of Onion Creek watershed modeled area. WASP segments begin at the recharge zone with Segment 1 and continue to Segment 34 where the model on Onion Creek was initiated. Even WASP segments are yellow while odd WASP segments are blue. The WWTP discharge was input into the WASP model just upstream of Segment 30. Baseline loads and flows are input into Segment 34, Flat Creek, Trib 2, Rocky Branch, Pier Branch, Jackson Branch, Gatlin Creek, South Onion, and Trib 9. Green points are locations along Onion Creek where samples were collected.

COA sample locations were selected based on site access, available substrate, and COA understanding of discharge outfall locations previously considered by the City of Dripping Springs. Specifically, Onion Prop Outfall – Trib and Onion Prop Outfall – Piped were the two locations that were previously proposed as WWTP discharge locations. The final point of the WWTP discharge was selected further upstream. The Onion @ HWY 12 site location was visited once but was dropped from the sample collection list due to lack of safe access to the creek along HWY 12.

Table 1: WASP segment length, width, and slope for Onion Creek mainstem. COA sampling, USGS gage, and proposed Dripping Springs WWTP discharge locations are listed with the WASP segment to which they are associated.

WASP Segment	Onion Location	Length (m)	Width (m)	Slope
Segment 1		1642.00	33.00	0.00233
Segment 2		1642.00	19.32	0.00233
Segment 3		1642.00	26.54	0.00233
Segment 4		1642.00	26.50	0.00233
Segment 5	USGS gage 08158700	1229.00	20.02	0.00229
Segment 6	Onion near Driftwood (COA sample location)	1229.00	18.78	0.00229
Segment 7		704.50	23.58	0.00132
Segment 8		704.50	22.96	0.00132
Segment 9		1018.00	23.00	0.00035
Segment 10		870.00	20.60	0.00406
Segment 11		751.00	24.66	0.00404
Segment 12		1308.00	19.20	0.00243
Segment 13		1308.00	29.10	0.00243
Segment 14		1308.00	20.30	0.00243
Segment 15		1308.00	29.30	0.00243
Segment 16		1151.67	19.50	0.0011
Segment 17		1151.67	15.70	0.0011
Segment 18		1151.67	13.70	0.0011
Segment 19	Onion US FM150 (COA sample location)	1027.00	13.73	0.00144
Segment 20		1027.00	13.00	0.00144
Segment 21		1205.67	21.70	0.00333
Segment 22		1205.67	24.67	0.00333
Segment 23	Onion Prop Outfall – Trib (COA sample location)	803.78	22.24	0.00333
Segment 24	Onion DS South Onion (COA sample location)	401.89	23.50	0.0033
Segment 25		467.65	20.87	0.00211
Segment 26	Onion Prop Outfall – Piped (COA sample location)	467.65	21.80	0.0021
Segment 27		935.33	20.11	0.00211
Segment 28	Onion @ HWY 12	935.33	17.38	0.00211
Segment 29		659.45	31.30	0.00319
Segment 30	WWTP Discharge	200.00	16.45	0.0032
Segment 31		459.45	16.05	0.0032
Segment 32		1318.90	26.50	0.00319

Segment 33		1318.90	25.60	0.00319
Segment 34	Model initiation	1318.90	25.00	0.00319

The remaining sites were sampled 5 times from early 2014 to late 2015 (Table 2) for water quality, benthic cover, benthic macroinvertebrate, and field parameter suites. Water quality parameters were analyzed from grab samples taken at each location, benthic cover parameters were analyzed from composite rock scrapings collected from at least 9 rocks located within a riffle at each site, and field parameters were collected by a sonde and a Marsh McBirney flow meter. Data collection followed COA standard procedures (WRE SOP 2016). Sampling was delayed occasionally due to scheduling conflicts between COA staff and private property owners, inclement weather, and periods of no flow in Onion Creek.

Table 2: Sampling schedule for Onion Creek sites. Includes the number of water quality (WQ) samples collected each sample event and the number of rocks composited for the benthic cover parameter suite.

Date	**03/12/2014**		**04/24/2014**		**07/24/2014**		**08/07/2015**		**12/16/2015**	
Site	WQ	BEN.	WQ	BEN.	WQ	BEN.	WQ	BEN.	WQ	BEN.
Onion Prop Outfall - Piped	3	9 rocks	Dry	Dry	Dry	Dry	3	--	3	9 rocks
Onion DS South Onion	3	9 rocks	1	9 rocks	1	9 rocks	3	--	3	9 rocks
Onion Prop Outfall – Trib	3	10 rocks	1	9 rocks	1	9 rocks	3	--	3	9 rocks
Onion US FM 150	3	10 rocks	1	9 rocks	1	9 rocks	3	--	3	9 rocks
Onion near Driftwood	3	11 rocks	1	9 rocks	1	9 rocks	3	--	3	9 rocks

While benthic macroinvertebrates were collected for this project, the data is not pertinent to the building of a WASP model. Thus benthic taxonomy will not be addressed in this report. The full list of parameters collected for the water quality, benthic cover, and field parameter suites can be seen in Table 3.

Table 3: List of parameters associated with the water quality, benthic cover, and field parameter suites collected by COA staff.

Parameter Suite	**Type**	**Parameter**
Water Quality	Nutrients	Ammonia as N, Nitrate+Nitrate as N, Total Kjeldahl Nitrogen as N, Orthophosphorus as P, Phosphorus as P
	Phytoplankton Biomass	Chlorophyll *a*, Pheophytin
	Organics	Organic Carbon
	Solids	Total Suspended Solids, Volatile Suspended Solids
	Ions/Minerals	Alkalinity, Chloride, Boron, Sodium, Magnesium, Calcium, Potassium, Sulfate, Fluoride, Strontium
Benthic Cover	Stoichiometry	Ammonia as N, Nitrate+Nitrite as N, Total Kjeldahl Nitrogen as N, Orthophosphorus as P, Phosphorus as P, Organic Carbon
	Solids	Total Suspended Solids, Volatile Suspended Solids
	Benthic Biomass	Chlorophyll *a*, Pheophytin
Field	Physical	Dissolved Oxygen, Water Temperature, pH, Conductivity, Instantaneous Flow

Parameters collected in the benthic cover parameter suite were reported in mg/L from the lab but were converted to mg/m^2. Total nitrogen was calculated by adding nitrate+nitrite and total Kjeldahl nitrogen. Benthic ash free dry weight (AFDW) was estimated from volatile suspended solids. The ratio of AFDW, organic carbon, total nitrogen, total phosphorus, and chlorophyll *a* at each site was calculated and the average ratios were included as 'Benthic Algae' constants in the WASP model. Other constants used in the model were initially taken from previous COA WASP modeling efforts in local water bodies but may have been altered in calibration for Onion Creek (Appendix A).

Initial conditions for nutrients and benthic algae biomass in calibration and validation were set to the average values of data collected by COA on the March 12, 2014, sampling event because it was the closest sampling event in time to the beginning of the simulation (Table 4). Inorganic and total phosphorus samples were always under the detection limits of 0.004 mg/L and 0.008 mg/L, respectively. Initial conditions for inorganic phosphorus were set to half of the detection limit concentration while organic phosphorus was set to 0.003 mg/L. For WASP segments that were not sampled, initial conditions for nutrients and benthic algae biomass were set to match the values of the closest COA sample location. For example, all WASP segments downstream of the Onion near Driftwood site were assigned initial values equal to the values that existed at Onion near Driftwood.

Table 4: Initial conditions used in WASP segments that are associated with the average values for samples collected on March 12, 2014.

Location	Ammonia (mg/L)	Nitrate (mg/L)	Organic Nitrogen (mg/L)	Inorganic Phosphorus (mg/L)	Organic Phosphorus (mg/L)	Benthic Algae (g DW/m^2)
Onion Prop Outfall – Piped	0.0187	0.095	0.227	0.002	0.003	2.5
Onion DS South Onion	0.014	0.031	0.163	0.002	0.003	5.6
Onion Prop Outfall – Trib	0.012	0.0198	0.119	0.002	0.003	1.2
Onion US FM150	0.012	0.101	0.126	0.002	0.003	2.1
Onion near Driftwood	0.016	0.0556	0.15	0.002	0.003	1.8

Daily flows and loads were input into WASP segments for Flat Creek, Trib 2, Rocky Branch, Pier Branch, Jackson Branch, south and north forks of Gatlin Creek, South Onion Creek, Trib 9, and segment 34 (most upstream location within the model for mainstem Onion Creek) (Figure 1). Flows at each of these inputs was estimated as a percentage of the flow at USGS gage 08158700 based on drainage area at the input location relative to the drainage area at United States Geological Survey (USGS) gage 08158700 (Table 5).

Table 5: Percent of drainage area at each flow input for the WASP model compared to the drainage area at USGS gage 08158700.

WASP segment	Percentage of drainage area
Flat Creek	5.76%
Trib 2	2.50%
Rocky Branch	3.74%
Pier Branch	4.38%
Jackson Branch	4.33%

North Gatlin Creek	4.13%
South Gatlin Creek	8.60%
South Onion Creek	19.32%
Trib 9	1.47%
Onion mainstem (segment 34)	25.47%

Daily loads were input into the same WASP segments. Loads were divided into storm loads and baseflow based on the amount of flow at USGS gage 08158700. If the daily flow at the gage was 50% higher than the previous days flow than the load that day was considered to be a storm load following established COA procedures. Otherwise, loads were considered baseflow. Baseflow loads were calculated as simply the baseflow concentration multiplied by the daily flow while the storm loads were calculated as the storm concentration of the pollutant multiplied by the change in flow. Baseflow and storm concentrations used in the load calculations can be seen in Table 6. Storm concentrations were taken from other COA work where stormwater event mean concentrations were developed for areas of similar drainage area and percent impervious cover (Glick 2009).

Table 6: Pollutant concentrations used in the baseflow and storm load calculations for the WASP model. EMC represents stormwater event mean concentration.

Parameter	Baseflow (mg/L)	Storm EMC (mg/L)
Ammonia	0.01	0.038
Nitrate	0.03	0.233
Organic Nitrogen	0.15	0.594
Inorganic Phosphate	0.002	0.022
Organic Phosphorus	0.003	0.022

For the modeling scenario that included the Dripping Springs WWTP discharge, additional flow and loads were input into the WASP segment labeled as WWTP Discharge in Figure 1. Loads were calculated by multiplying the WWTP pollutant concentrations by the proposed discharge of 995,000 gallons per day. WWTP pollutant concentrations were taken as a combination of the requested permit concentrations and adding nitrate and organic nitrogen concentrations based on other WWTP with no total nitrogen limits (Porras 2013) (Table 7).

Table 7: Pollutant concentrations used in the WWTP discharge load calculations for the WASP model

Parameter	WWTP (mg/L)
CBOD	5
Ammonia	2
Nitrate	25
Organic Nitrogen	2
Inorganic Phosphate	0.5

Results

Flow

Prior to calibration for nutrients or benthic algae biomass, the modeled flow was compared to the flow at USGS gage 08158700 to ensure the model was simulating flow through Onion Creek accurately. Modeled flow was taken from WASP segment 5, which is the closest segment to the location of the USGS gage. There was no significant difference between the daily gage flow and daily model flow at WASP segment 5 from January 1, 2000 to October 26, 2015 (Table 8; Figure 2, 3).

Table 8: Daily mean (95% confidence intervals) and median flow (cfs) for USGS Gage 08158700 on Onion Creek and the modeled WASP flow in Segment 5 from January 1, 2000 to October 26, 2015. Statistics for the difference between the daily observed and daily modeled flows during this time period are also presented. No significant difference existed between the daily observed and modeled flow.

Parameter	Mean	95% CI	Median
Gage Flow (cfs)	45.59	41.17 to 50.01	4.70
Model Flow (cfs)	43.76	39.59 to 47.94	4.53
Percent Difference	-0.90	-2.02 to 0.23	--

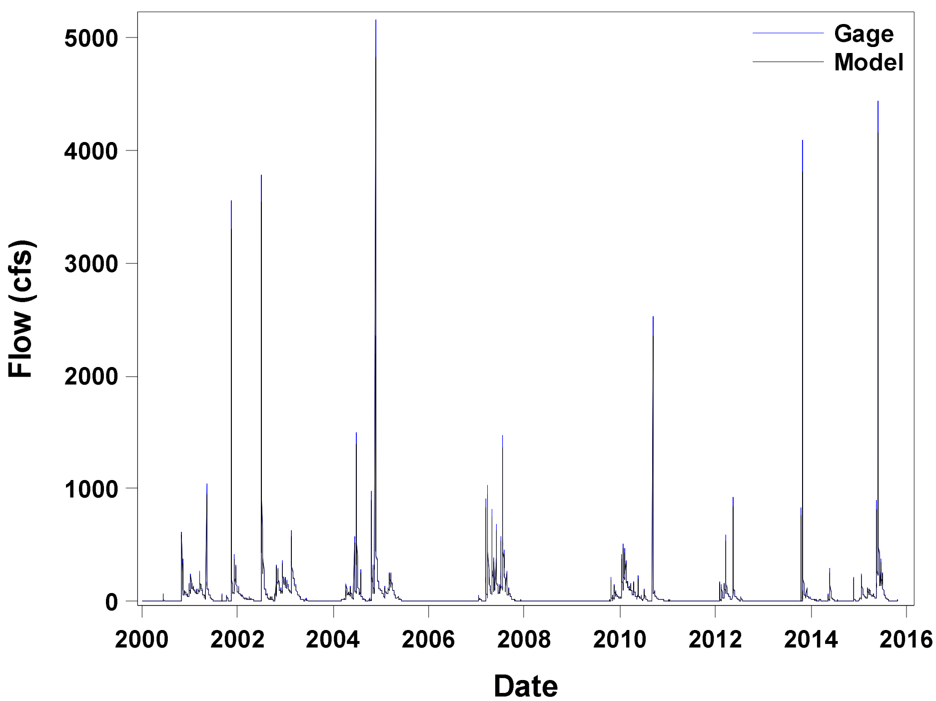

Figure 2: Flow at USGS Gage 08158700 on Onion Creek vs WASP modeled flow at a similar location (WASP Segment 5).

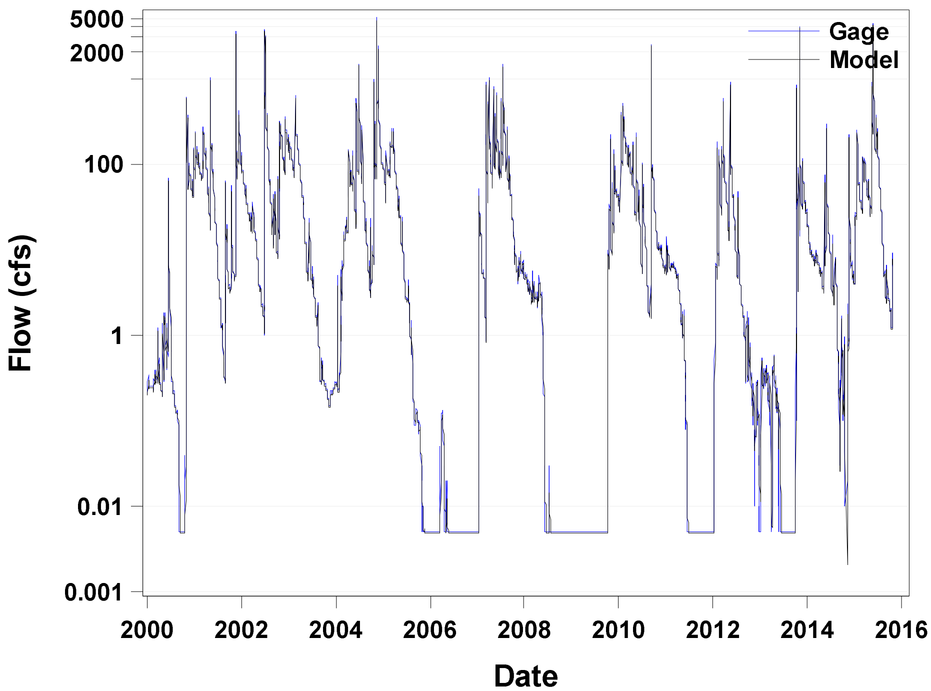

Figure 3: Flow at USGS Gage 08158700 on Onion Creek vs WASP modeled flow at a similar location (WASP Segment 5) on a log scale to better visually assess differences during low flow.

Calibration: Nutrients and Algae

Calibration scenarios were run from January 1, 2014, to October 26, 2015. During this time period the COA conducted 4 out of 5 of its sampling events with one sample occurring after the scenarios time period ended. The WASP segment and COA sample collection location closest to the USGS gage were used for model calibration. Model constants were adjusted until the water column nutrients (ammonia, nitrate, organic nitrogen, inorganic phosphorus, and total phosphorus), benthic biomass, nitrogen in the benthic algae, and phosphorus in the benthic algae output from WASP segment 6 were similar to collected data at Onion near Driftwood (Figure 4). Orthophosphorus was collected in the field and matched with inorganic phosphorus output from the model. The final model constants used to attain this calibration can be seen in Appendix A. While most of the modeled water column nutrients and benthic nutrient concentrations are well within range of collected data, the modeled benthic biomass and chlorophyll *a* did not match the level collected in July 2014. Biomass and chlorophyll *a* tend to increase in the model as nitrogen and phosphorus available to the cells increase, the temperature of the water is optimal, and there is enough available light. Inputs for light are on a monthly basis so it is difficult for the model to predict every daily change to algal biomass. The model predictions should be viewed as a more generalized prediction of algal biomass in Onion Creek.

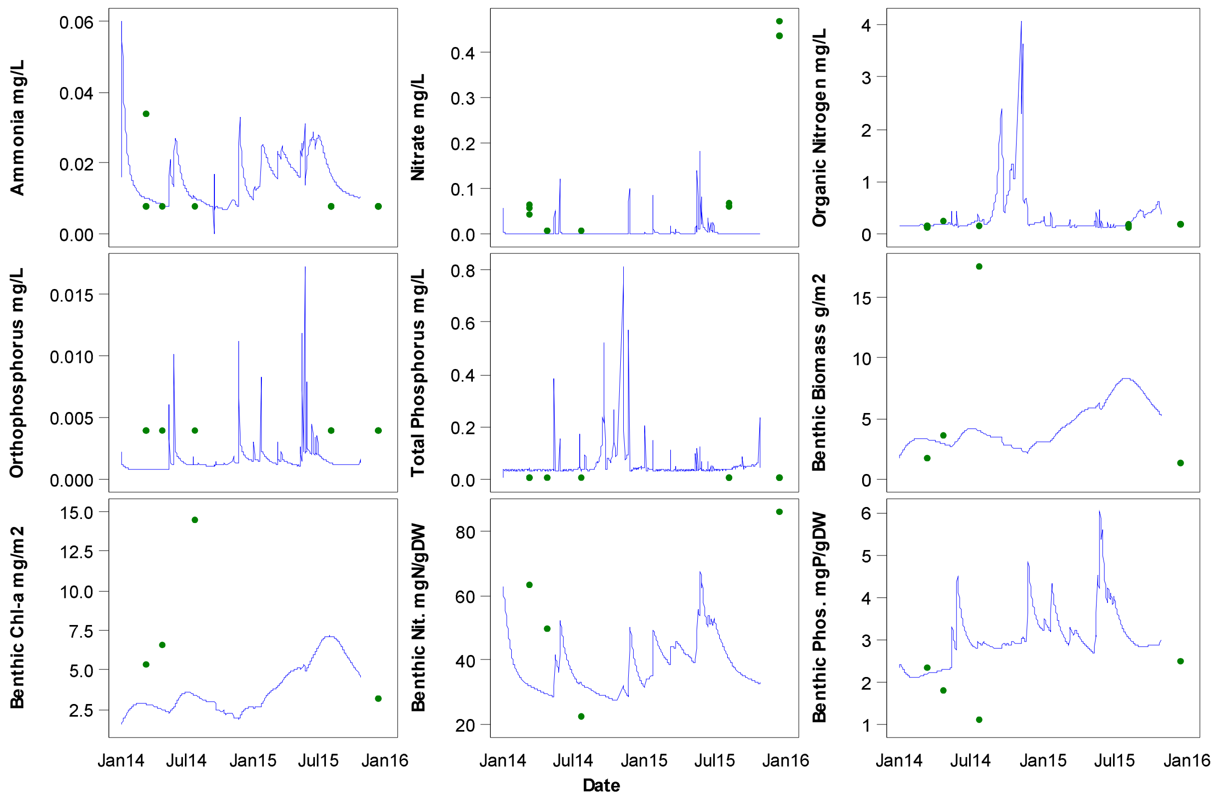

Figure 4: WASP model output for segment 6 (blue line) and data collected by COA at Onion near Driftwood (green dots).

Once the model was calibrated to the Onion near Driftwood site location, the other COA site locations were used to validate the model results. Output from WASP segment 19 was paired with data collected at Onion US FM 150 (Figure 5), output from WASP segment 23 was paired with data collected at Onion Prop Outfall – Trib (Figure 6), and output from WASP segment 24 was paired with data collected at Onion DS South Onion (Figure 7). Onion Prop Outfall – Piped was not used in validation as only two points of data were collected and only one of those points was within the simulation run time. The nutrient output was well within range of the collected data at Onion US FM 150. Modeled benthic biomass and chlorophyll *a* was close to collected data points in 2014. The concentrations were slightly elevated in the model for 2015 when compared to 2014, but no data was collected from the benthic cover during this time period for comparison to the model output. Modeled output was well within range of collected data at Onion Prop Outfall – Trib and at Onion DS South Onion. Since the model output was generally in the range of collected data at all site locations, the output should be able to be used for general estimates at any point within the modeled portion of Onion Creek.

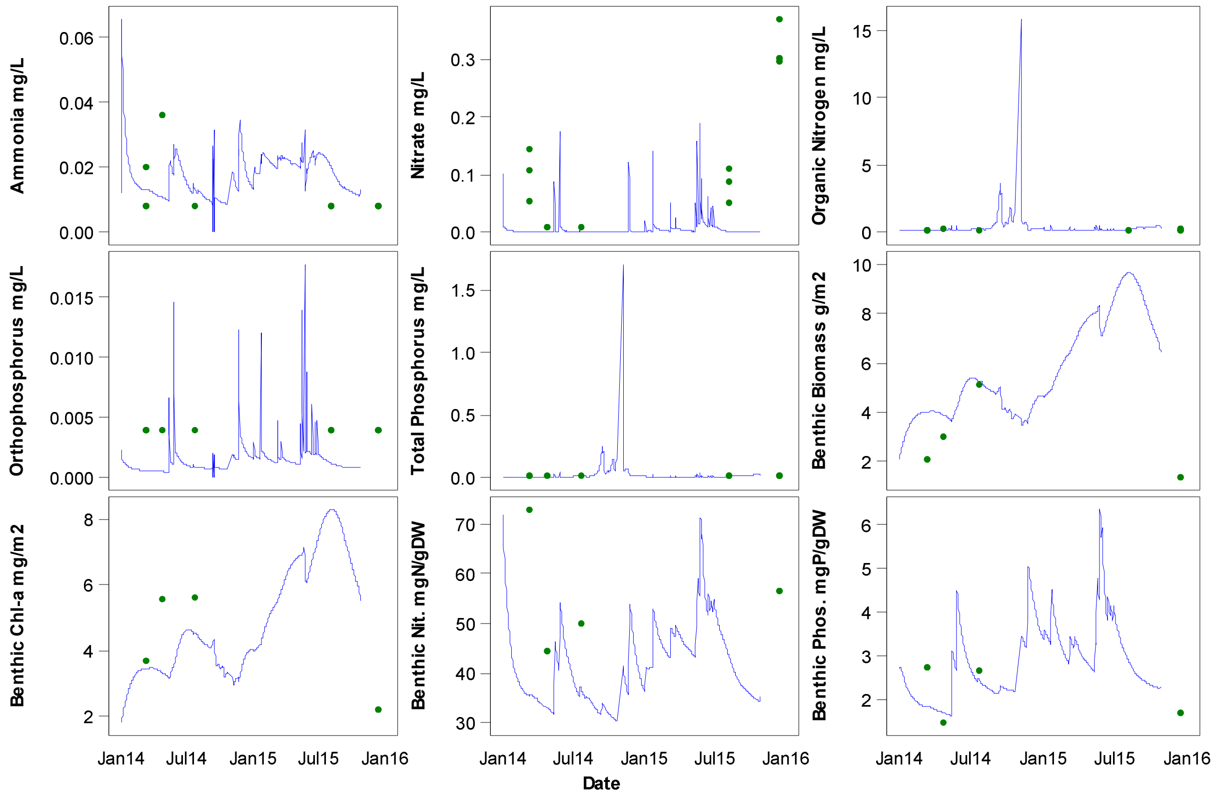

Figure 5: WASP model output for segment 6 (blue line) and data collected by COA at Onion US FM 150 (green dots).

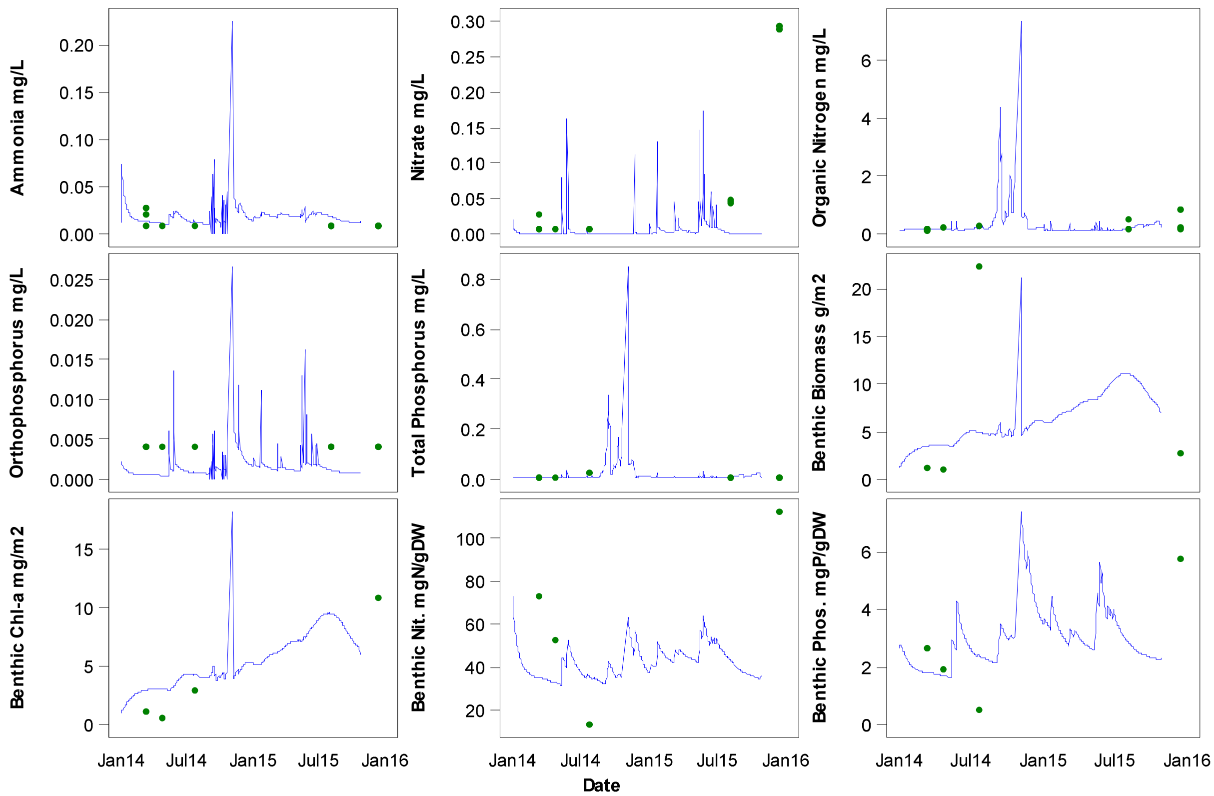

Figure 6: WASP model output for segment 6 (blue line) and data collected by COA at Onion Prop Discharge –Trib (green dots).

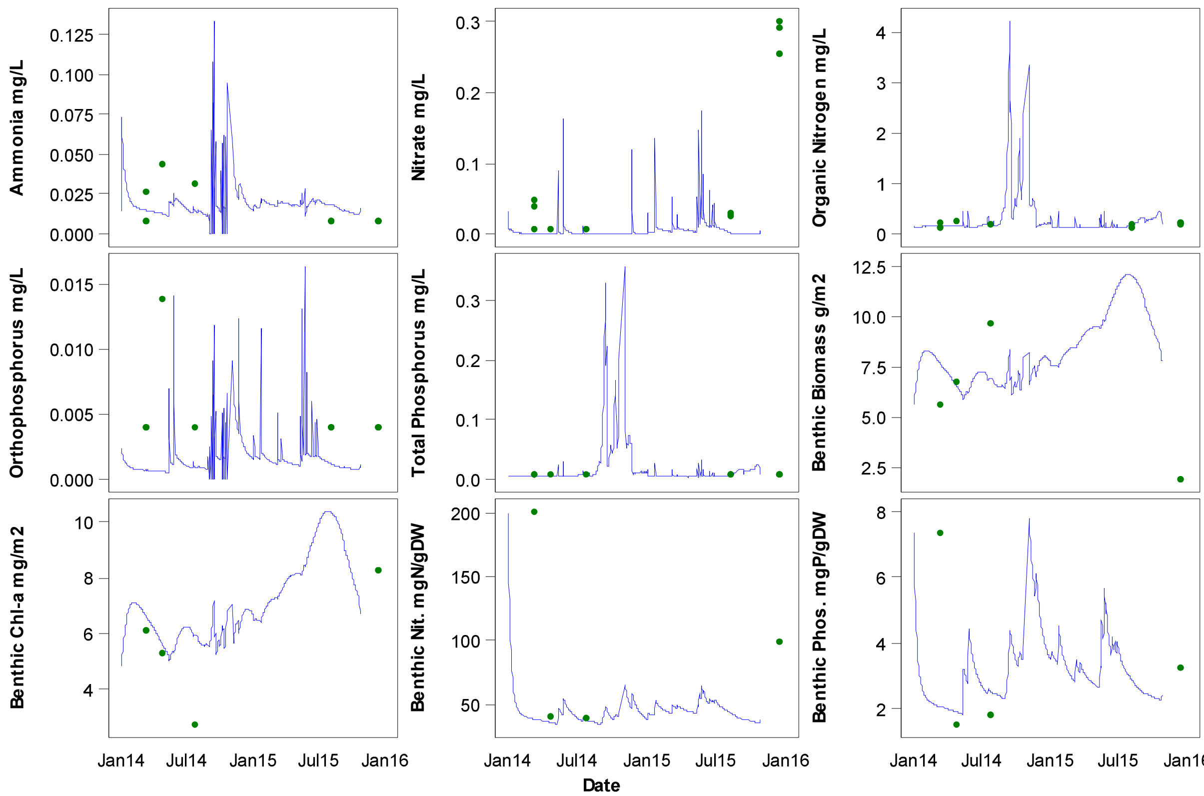

Figure 7: WASP model output for segment 6 (blue line) and data collected by COA at Onion DS South Onion (green dots).

Baseline and Discharge Scenarios

Following calibration for nutrients and algae biomass, two scenarios were run in WASP to determine the potential impact of the proposed Dripping Springs WWTP discharge. Both scenarios were run from January 1, 2000, to October 26, 2015. The first scenario had no further inputs into the model and was considered the Baseline scenario. The second scenario included a wastewater discharge of 995,000 gallons per day input into the WASP segment labeled WWTP Discharge with nutrient loadings described above for the Dripping Springs WWTP discharge and was considered the Discharge scenario.

Annual mean benthic chlorophyll *a* in Onion Creek was calculated for both scenarios at a distance of 200 m (656 ft.) downstream of where the WWTP discharge is proposed to intersect Onion Creek (Figure 8). This was done to get a detailed comparison of mainstem Onion Creek immediately downstream of the discharge under both scenarios. In the Baseline scenario, annual mean benthic chlorophyll *a* at this location is always under 25 mg/m^2 and in most years is actually under 10 mg/m^2. This would clearly indicate that Onion Creek is in an oligotrophic status according to an oligotrophic/mesotrophic threshold of 36 mg/m^2 suggested by Dodds (2006) for systems where phosphorus is most likely a limiting factor in algae growth like many Austin creeks. Under the Discharge scenario, the annual mean benthic chlorophyll *a* concentrations are approximately 50 mg/m^2 from 2001 to 2015. The annual mean benthic chlorophyll *a* concentration in 2000 was above 30 mg/m^2 and more than 6 times the Baseline scenario annual mean. The mean concentration in 2000 was not above the suggested threshold due to the fact that benthic algae concentrations begin very low and slowly rise during the first year of the discharge. With the exception of the first year of the scenario, the proposed discharge would drive productivity in Onion Creek directly downstream of the WWTP discharge from an oligotrophic status well into the mesotrophic status range.

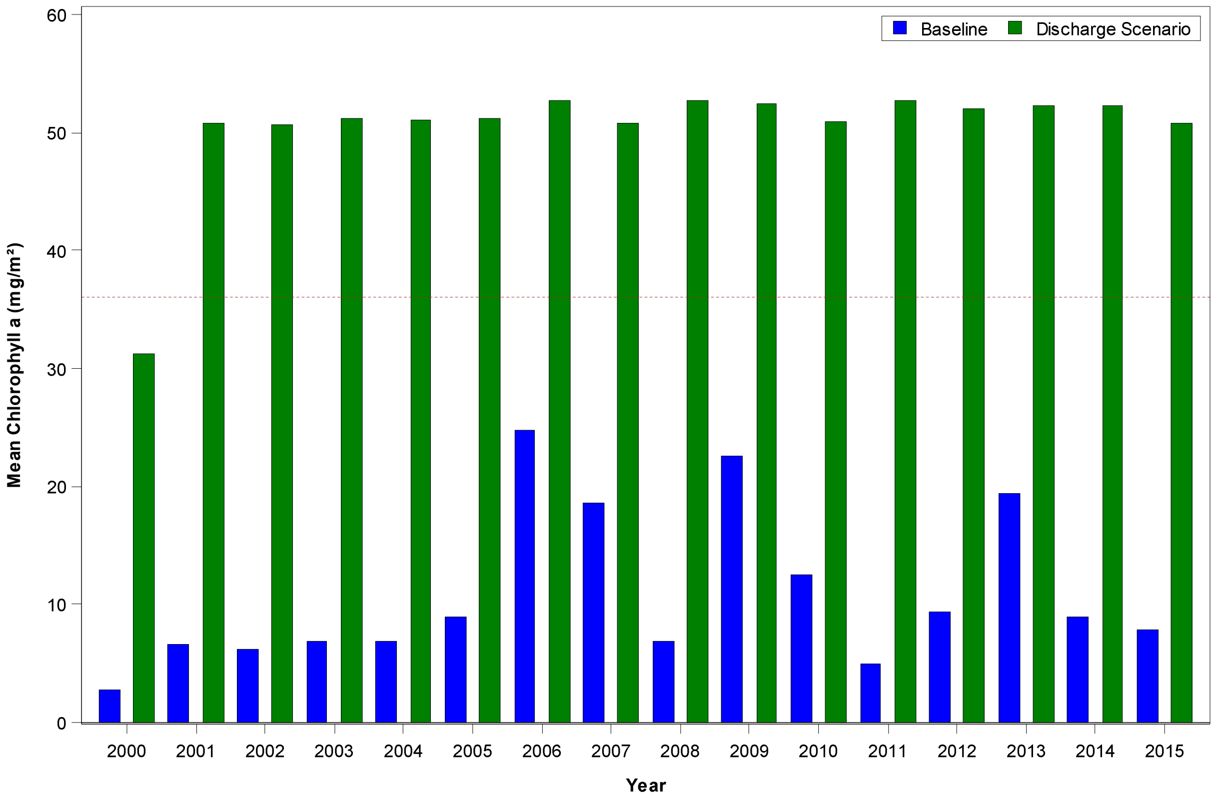

Figure 8: Annual mean benthic chlorophyll *a* (mg/m^2) from modeled data on Onion Creek at a distance of 200 m (656 ft.) from where the Dripping Springs WWTP effluent would enter Onion Creek. Means for the Baseline scenario where no effluent is discharged are blue while means for the Discharge scenario are green. Onion Creek would be considered in an oligotrophic state in the Baseline scenario but in a mesotrophic state in the Discharge scenario using the threshold proposed by Dodds (2006).

To evaluate the spatial extent of water quality impacts from the proposed WWTP discharge, yearly plots of the of the annual mean benthic chlorophyll *a* were constructed from the point where the discharge enters Onion Creek to the Edwards Aquifer Recharge Zone boundary (Figure 9). Under the Discharge scenario Onion Creek will be in a mesotrophic status for 14099.43 to 19644.43 m (8.76 to 12.20 miles) depending on the year. On the map in Figure 1, that would be a considerable stretch of Onion Creek from the point where the WWTP discharge enters Onion Creek to either just downstream of Pier Branch (8.76 miles) or extending down to just upstream of Trib 2 (12.20 miles). Under the Discharge scenario, the concentration of benthic chlorophyll *a* does not return to baseline concentrations prior to reaching the recharge zone boundary with the exception of the year 2006 which was a dry year.

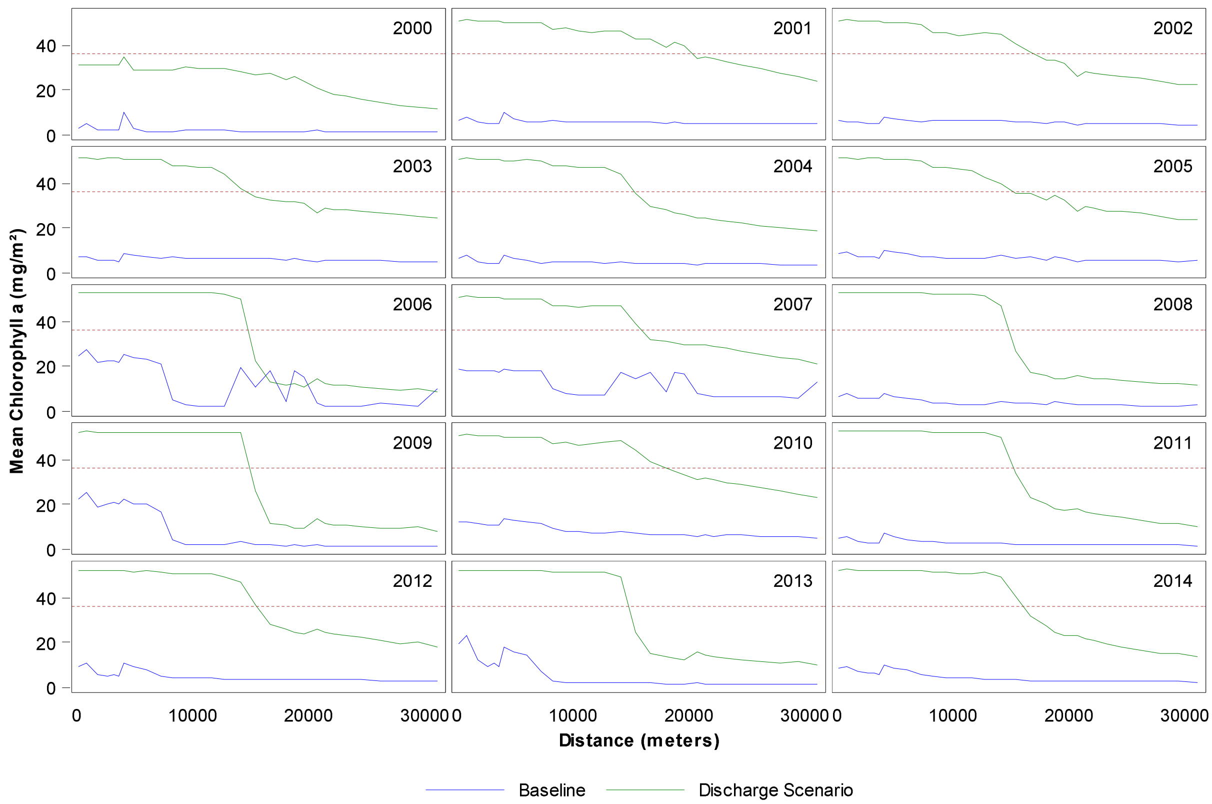

Figure 9: Annual mean chlorophyll *a* against distance (meters) from the WWTP discharge. Blue lines indicate chlorophyll *a* concentrations without the discharge while green lines indicate chlorophyll *a* concentrations with the discharge. The brown line indicates the threshold between oligotrophic and mesotrophic status based on benthic chlorophyll *a* (36 mg/m^2) proposed by Dodds (2006). In the presence of the WWTP discharge, Onion Creek will degrade to a mesotrophic status at the point of discharge and remain in that status for 14099.43 to 19644.43 m (8.76 to 12.20 miles) depending on the year.

Conclusion

The predicted increase in benthic chlorophyll *a* due to nutrient enrichment from the proposed City of Dripping Springs WWTP effluent shows that Onion Creek would be degraded from a low productivity oligotrophic system to a higher productivity mesotrophic system for approximately 9 to 12 miles depending on rainfall in a given year.

Discussion

More stringent nutrient treatment standards, reductions in effluent volume, lower discharge frequency, discharging only when Onion Creek ambient flow is above some threshold, or expansion of land application of effluent would reduce the potential for degradation to this portion of Onion Creek. Such restrictions can be modeled to determine what concentration of nutrients, volume of effluent, and discharge frequency would impact the creek the least. Before a discharge permit is issued to the City of Dripping Springs by TCEQ, restrictions developed from additional analysis should be examined and a protective set of conditions written into the permit. The current proposal should not be accepted as it results in significant degradation of the water quality of Onion Creek based on the modeling results in this report.

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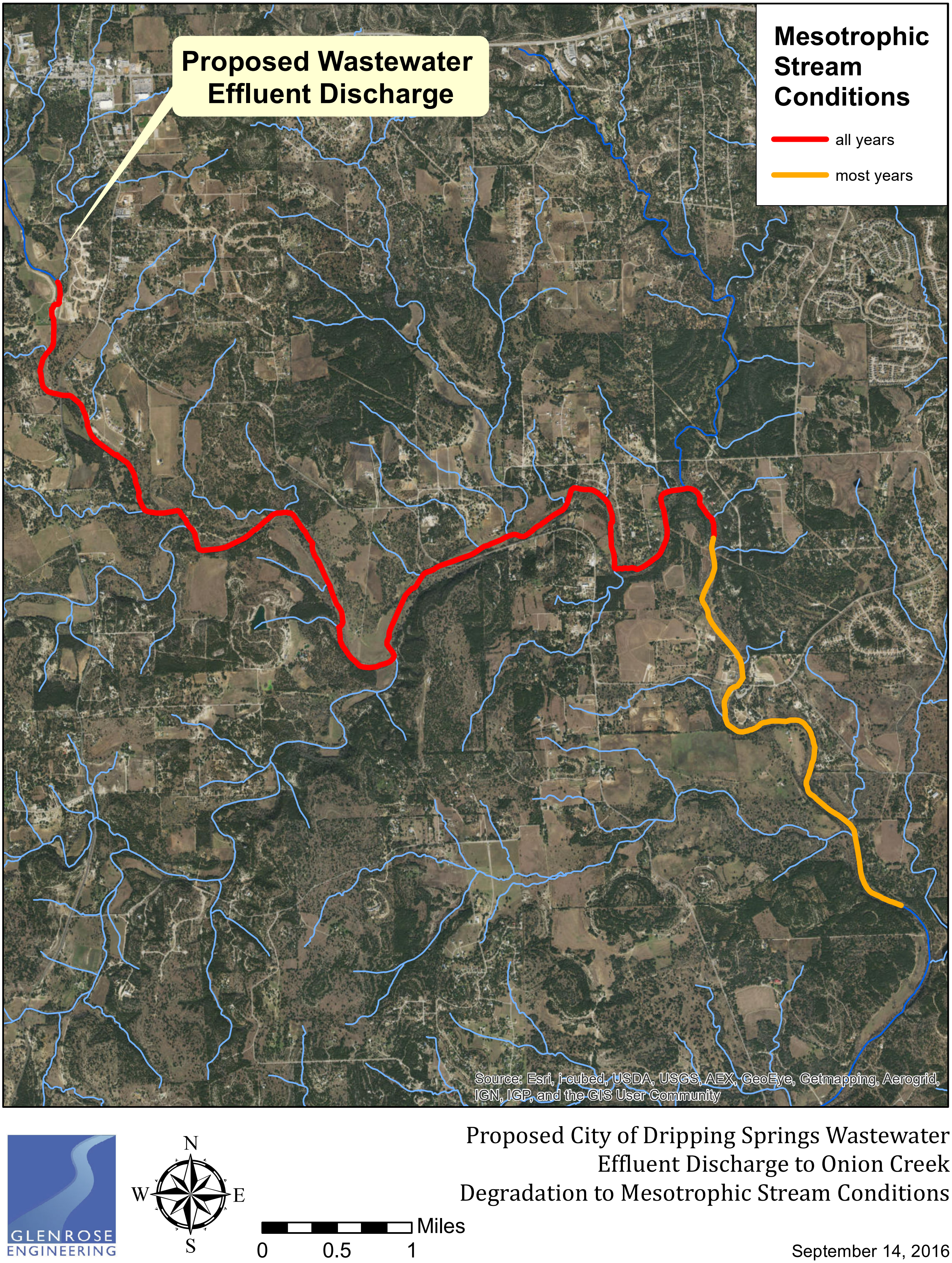
Appendix A: Nutrient and Algal Constants.

Inorganic Nutrient Kinetics	
Nitrification Rate Constant @ 20 C (1/day)	0.13
Nitrification Temperature Coefficient	1.08
Half Saturation Constant for Nitrification Oxygen Limit	2
Denitrification Rate Constant @ 20 C (1/day)	0
Denitrification Temperature Coefficient	1.04
Half Saturation Constant for Denitrification Oxygen Limit	0.1
Organic Nutrients	
Detritus Dissolution Rate (1/day)	0
Dissolved Organic Nitrogen Mineralization Rate Constant	0.075
Dissolved Organic Nitrogen Mineralization Temperature Coefficient	1.08
Dissolved Organic Phosphorus Mineralization Rate Constant	0.22
Dissolved Organic Phosphorus Mineralization Temperature Coefficient	1.08
CBOD	
CBOD(1) Decay Rate Constant @ 20 C	0.4
CBOD(1) Decay Rate Temperature Correction Coefficient	1.05
CBOD(1) Half Saturation Oxygen Limit	0.4
Dissolved Oxygen	
Oxygen to Carbon Stoichiometry Ratio	2.67
Global Reaeration Rate Constant @ 20 C	7
Light	
Light Option	1 – uses input light
Include Algal Self Shading Light Extinction in Steele	0
Background Light Extinction Coefficient	0.813
Benthic Algae	
Benthic Algae D:C Ratio	9.2
Benthic Algae N:C Ratio	0.41
Benthic Algae P:C Ratio	0.017
Benthic Algae Chla:C Ratio	0.0079
Benthic Algae 02:C Production	2.69
Growth Model	1 – First Order
Max Growth Rate	0.4
Temp Coefficient for Benthic Algal Growth	1.05
Carrying Capacity for First Order Model	500
Respiration Rate Constant	0.2
Temperature Coefficient for Respiration	1.06
Internal Nutrient Excretion Rate Constant	0.1
Temperature Coefficient for Nutrient Excretion	1.05
Death Rate Constant	0.15
Temperature Coefficient for Algal Death	1.05

Half Saturation Uptake Constant for Extracellular Nitrogen	0.1
Half Saturation Uptake Constant for Extracellular Phosphorus	0.02
Light Option	2 – Smith
Light Constant for growth	135
Benthic Algae ammonia preference	0.025
Minimum Cell Quota of Internal Nitrogen for Growth	10
Minimum Cell Quota of Internal Phosphorus for Growth	0.5
Maximum Nitrogen Uptake Rate	100
Maximum Phosphorus Uptake Rate	10
Half Saturation Uptake Constant for Intracellular Nitrogen	10
Half Saturation Uptake Constant for Intracellular Phosphorus	2
Fraction of Benthic Algae Recycled to Organic N	0.1
Fraction of Benthic Algae Recycled to Organic P	0.1
Phytoplankton	
Nitrogen to Carbon Ratio	0.25
Phosphorus to Carbon Ratio	0.025
Carbon to Chlorophyll Ratio	50
Maximum Growth Rate Constant @ 20 C	1
Phytoplankton Growth Temperature Coefficient	1.08
Optimal Temperature for Growth	20
Shape parameter for below optimal temperature	0.05
Shape parameter for above optimal temperature	0.05
Respiration Rate Constant @ 20 C	0.01
Respiration Temperature Coefficient	1.045
Death Rate Constant	0
Death Rate due to salinity toxicity	0
Grazability	0
Half-Saturation Constant for N	0.1
Half-Saturation Constant for P	0.1
Nitrogen fixation	0 – no
Optimal Light Saturation	125
Fraction of Death Recycled to Organic N	0.5
Fraction of Death Recycled to Organic P	0.5

Attachment B



GLENROSE ENGINEERING

Proposed City of Dripping Springs Wastewater
Effluent Discharge to Onion Creek
Degradation to Mesotrophic Stream Conditions

September 14, 2016

Attachment C

Surface-Water and Groundwater Interactions Along Onion Creek, Central Texas

Conference Paper · July 2016

Brian B. Hunt
Barton Springs/Edwards Aquifer Conservatio…

In Press

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Surface-Water and Groundwater Interactions Along Onion Creek, Central Texas

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ABSTRACT

Onion Creek is an important hydrologic link between two major aquifers in Central Texas. Multiple small springs discharging from the Trinity Aquifers sustain base flow in Onion Creek, which in turn recharges the Edwards Aquifer, ultimately discharging at Barton and San Marcos Springs. The creek generally contains clear, low nutrient water with high ecological and recreational value. This watershed is rapidly being developed and is experiencing significant population growth and land use changes, thus increasing demand for water supplies and potentially affecting regional hydrology. Several wastewater treatment plants are operating in the watershed with additional treatment plants being planned. Despite the critical importance of Onion Creek to the community, no comprehensive gain-loss studies have been conducted that characterize the surface and groundwater interactions across the Trinity (Upper Glen Rose) and Edwards Aquifers. This paper presents the results of a flow study in Onion Creek and its tributaries extending 46 miles from the headwaters in Blanco County to downstream of the Edwards Aquifer recharge zone in Hays County. A total of 69 flow sites were established and acoustic Doppler velocimeters (ADV) were used to make 139 wading flow measurements from January through December 2015. Detailed geologic, hydrogeologic, and geochemical data were incorporated into the evaluation to understand the hydrogeologic significance of the data. Two synoptic flow-measurement events were done during low and high flow conditions in July and November 2015, respectively. This study reveals complex surface and groundwater interactions in the Onion Creek watershed. Flow losses are documented to occur along a creek reach underlain by the Upper Glen Rose. These losses combined with other hydrogeologic and geochemical data suggest Onion Creek provides some recharge to the Middle Trinity Aquifer in those reaches. A better understanding of the surface water and groundwater interactions along the creek is important for groundwater and surface-water management in an area undergoing significant population growth.

INTRODUCTION

Onion Creek is an important hydrologic link between two major aquifers in Central Texas. Multiple small springs, discharging from the Upper Trinity Aquifer (Upper Glen Rose Member), sustain base flow in Onion Creek that in turn recharges the Edwards Aquifer. Ultimately, this water discharges at Barton and San Marcos Springs. Previous studies have characterized the stream losses along the Blanco River over the Edwards Aquifer Recharge Zone (Slade et al., 1986; Smith et al., 2001) and more recently portions of the Middle Trinity Aquifer (Smith et al., 2014). Muller (1990) conducted a study of groundwater in the Dripping Springs area and indicated Onion Creek could be a source of recharge to the Dripping Springs Water Supply System wells completed in the Middle Trinity Aquifer. However, no comprehensive gain-loss studies have been conducted that characterize the surface and groundwater interactions in the upper Onion Creek watershed. Such information is critical to the conceptual model of the aquifer and future numerical models.

The purpose of this study is to characterize the groundwater and surface-water interactions in the upper Onion Creek watershed primarily underlain by the Upper Glen Rose Member. The study integrates flow measurements taken during two synoptic events with hydrogeologic and geochemical data.

STUDY AREA

The area under study is the upper watershed of Onion Creek underlain by Lower Cretaceous strata. Data were collected on the main Onion Creek channel and many of its tributaries extending about 46 miles from the headwaters in eastern Blanco County to downstream of the Edwards Aquifer Recharge Zone in Hays County (Fig. 1). Within the upper watershed, baseflows are fed by multiple fresh-water springs along its path that issue from Lower Cretaceous, Trinity Group strata. (Upper Glen Rose Member). This portion of the creek is described as an overall gaining stream and is mapped as the “Contributing Zone” to the Edwards Aquifer Recharge Zone for regulations guiding construction (TCEQ, 2008). Onion Creek is recognized as a losing stream as it crosses the Balcones Fault Zone (BFZ) and the outcrop of the Edwards Group units, providing about a third of the recharge to the Barton Springs segment of the Edwards Aquifer (Slade et al., 1986). East of Buda and downstream of the study area, Onion Creek flows another 27 miles over Upper Cretaceous and Quaternary units before its confluence with the Colorado River near Austin, Texas.

The hydrology of Onion Creek is dynamic and subject to both severe drought and flash floods. Multiple factors contribute to these severe events, but the Hill Country terrain and the Balcones Escarpment are significant geographic features (Slade and Patton, 2002). Drought significantly affected the study area in 2009 and 2011 when portions of the creek, which normally contain perennial flow, ceased flowing. Flood waters frequently over flow creek banks and inundate homes and roads. An evaluation of hydrologic data in Central Texas demonstrated increasing variability and decreasing baseflows over time (Hunt et al., 2012).

GEOLOGIC SETTING

Onion Creek traverses two major physiographic provinces in Central Texas: the eastern edge of the Edwards Plateau (also known as the Hill Country) and the western edge of the Gulf Coastal Plains (also known as the Blackland Prairies) defined by the prominent Balcones Escarpment. These provinces are underpinned by the Cretaceous geology of the region and its geologic structures (Figs. 1 and 2; Hill and Vaughn, 1898).

During the early Cretaceous period, sediments were deposited in an overall transgressive carbonate platform setting that greatly influenced the lithology, textures, and structures in the rocks. These shallow marine units form a heterogeneous package of stacked carbonate sequences reflecting shallow shelf to supratidal and restricted environments. The units were never buried deeply, thus preserving primary and secondary porosity and permeability. Later structural movement along the BFZ fractured the brittle limestones and dolomites in the study area. Uplift, erosion, and formation of the Hill Country has exposed these carbonate units to infiltration of meteoric water, and therefore karst processes (Barker et al., 1994; Barker and Ardis, 1996; Hunt et al., 2011). Regional stratigraphy is presented in Figure 2.

Lithostratigraphy of the Upper Onion Creek Watershed

The Upper Glen Rose Member of the Trinity Group crops out over much of the western reaches of Onion Creek. Although previous authors had mapped the Upper Glen Rose (Barnes, 1974; DeCook, 1963; Grimshaw, 1970; Collins, 2002a-c), the important zonation of the strata into recognizable, correlative units was defined by Stricklin et al. (1971). Subsequent detailed investigations by Muller (1990), Ward and Ward (2007), and Clark and Morris (2015) has further refined the lithostratigraphy (Fig. 3). Measured surface sections and published analyses were tied to the subsurface units through correlation with a series of geophysical logs and samples of drill cuttings from area water wells in this study (Figs. 1-3). Much of the Upper Glen Rose area in western Hays County is covered or intrastratal karst (Klimchouk and Ford, 2000). Surface karst features, including caves, sinkholes, and subsurface karstic porosity in water-well boreholes are common (personal communication, Alex S. Broun).

The Oswald well anchors the structural cross section (A-A') in the west, proximal to the headwaters of Onion Creek (Figs. 1 and 3). The Upper Glen Rose Member is 355 ft thick at Oswald and is subdivided into eight informal lithologic units, which correlate to the classic work of Stricklin et al. (1971). At the base of the section is the Lower Glen Rose Member with the regionally recognized "Corbula Bed" (Stricklin et al., 1971; Scott et al., 2007). At the top of the interval the distinctive Walnut Clay formation, with its characteristic Ceratostreon texanum oyster, was correlated to the Divide Pass measured surface section (Fig. 3). The hydrostratigraphy of the Upper Glen Rose, as defined by Muller (1990), is correlated to the Stricklin et al. (1971) interpreted unit subdivision and the measured section of this study (Fig. 3).

Upper Glen Rose Unit 1 is 20 ft thick in the Oswald borehole and consists of dolomite, dolomitic mudstone and siltstone. This interval is identified as Unit 1 "Solution Zone" in Stricklin et al. (1971) and is correlated to the "Lower Evaporite" of Clark and Morris (2015). It is a prominent marker unit and can be identified in both surface and subsurface locations. Gypsum beds are present in the subsurface as evidenced by cuttings samples and low gamma ray geophysical signature. In outcrop, the evaporite is altered leaving characteristic “boxwork” textures, usually dolomite in composition. Unit 1 is commonly associated with seeps and springs although, as Mueller (1990) points out, “all units in the Dripping Springs Valley can yield small quantities of fresh water”.

Unit 2 at the Oswald well is 50 ft thick and contains grainstone to wackestone, micritic-skeletal-coated grains and calcareous mudstone. Unit 3, which is 50 ft thick, can be identified in both the surface and subsurface cuttings characterized by the presence of abundant Orbitolina texana (foraminifera) fossils in a calcareous mudstone. Mollusk steinkerns and skeletal fragments are also common in argillaceous grainstone, packstone, and clay units.

Unit 3 was identified by Muller (1990) as the basal “aquitard” for the “shallow aquifer” contained in the overlying Units 4 and 5. This clay-prone unit outcrops in the vicinity of Dripping Springs (Fig. 3). It is located in the Onion Creek tributary bed of Blue Creek and others. It underlies units 4 and 5 in the city where shallow perched water is found at depths of 18 to 20 ft in construction boreholes.

Units 4 and 5 are a combined 55 ft thick in the Oswald well. They consist of interbedded dolomitic packstone, calcarenite, and mudstone. These two units form what Muller (1990) describes as the “shallow aquifer” in the Dripping Springs area. Several seeps and springs are associated with these units including the primary springs in town (Dripping Springs and Walnut Springs).

Unit 6 is 80 ft thick at the Oswald location where it consists of grainstone-packstone, skeletal-peloid-micritic limestone with miliolids, monoplurid rudists, and mudstone. It outcrops at the Dreyer borehole location and contains the Loriolia rosana maker bed (Figs. 1 and 3).

Units 7 and 8 (undifferentiated at the Oswald well) are about 100 ft thick and composed of alternating dolomites and dolomitic marls. Although poorly fossiliferous in the subsurface, beds with oysters and casts (steinkerns) of bivalves and gastropods are found in outcrop north of Dripping Springs.

Upper Glen Rose strata can be correlated from the Blanco County outcrop eastward along the Onion Creek watershed through the use of geophysical logs, cuttings samples, and outcropping beds. Cross section A-A’ (Figs. 1 and 2) connects a series of water-well boreholes with good geophysical log correlation from Oswald in the west, to the Maddux well in the east. Critical to the results of this study is the erosional thinning of the Upper Glen Rose section from 355 ft thick at the Oswald well to 40 ft thick at the Dripping Springs Public Water Supply Well No.1 (DSWSC #1; Fig. 2). Erosional thinning removed Unit 3 from portions of Onion Creek (Fig. 2) and in the bed of Onion Creek near DSWSC #1, the Upper Glen Rose Unit 1 is interpreted to be less than 20 ft thick. No Lower Glen Rose outcrop with the “Corbula Bed” was identified in the creek (Fig. 2), but the shallow contact is clearly recognized in nearby borehole geophysical logs of the DSWSC wells.

Structure

Trinity Group strata dip eastward at 1 to 2 degrees from the outcrop of Paleozoic rocks of the Llano Uplift to the BFZ due to structural (depositional) dip. In the BFZ dips increase to the east due to structural (faulting) influences. Surface erosion from the Onion Creek headwaters downstream has a steeper gradient than the depositional dip, therefore older strata are exposed the farther east one moves from the headwaters until reaching the BFZ (Fig. 2).

Structures are known to influence groundwater flow in the Trinity Aquifer in the region (Hunt et al., 2015); however, there are no significant faults from the headwaters to about mile 29 downstream in the study area where the first mapped fault of the BFZ is encountered (Figs. 1 and 3). Minor faults and fractures are present above mile 29 (Fig. 1). Below about mile 29, northeast-southwest trending normal faults of the BFZ have been mapped cutting across Onion Creek and appear to influence the course of the creek. Monoclinal-folding, trending northeast-southwest, associated with suspected fracture zones has been interpreted from structural mapping of the Cow Creek formation, but these features were not observed at the surface (Wierman et al., 2010). The Upper Glen Rose west of the BFZ and may mask fault trends in the study area. For example, northwest-trending faults in the Lower Glen Rose exposed along the Blanco River are along strike with fractures and minor faults and lineament trends mapped in the Onion Creek watershed (Fig. 1).

Fracturing plays an important role in the hydrogeology of the creek and solution-enlarged fractures are commonly observed. Thin-bedded limestones and dolomites of the Upper Glen Rose are commonly fractured and contain multiple-modal fracture sets. Vertical fractures exposed in outcrop cut through the more competent carbonate beds, but show no obvious indications of slippage.

HYDROGEOLOGY

The Edwards and Trinity Aquifers are the two major aquifer systems in the study area. The Trinity Aquifers are composed of diverse Trinity Group units, which are organized into three regional hydrostratigraphic units: the Upper, Middle, and Lower Trinity. The Edwards Aquifer overlies the Trinity Aquifers, but faulting has juxtaposed the two aquifers in the BFZ (Ashworth, 1983; Barker and Ardis, 1996; Barker et al., 1994; Mace et al., 2000). The Trinity Aquifers underlie the western portion of the study area while the Edwards Aquifer underlies the eastern portion of the study area.

The Upper Trinity Aquifer is composed of the Upper Glen Rose Member and is discussed in the next section. The Middle Trinity Aquifer consists of the Lower Glen Rose, Hensel, and Cow Creek Formations. All units of the Middle Trinity are carbonates and karstic. Underlying the Cow Creek is the Hammett Shale, a regional confining layer separating the Middle and Lower Trinity Aquifers. The Cow Creek is the most prolific regional aquifer unit in the Middle Trinity (Fig. 2). The Hensel is a water-bearing unit west of the study area and eastward becomes a confining, or semi-confining unit, which is locally breached with fractures and solution features. The Lower Glen Rose is also an important aquifer unit within the Middle Trinity Aquifer with the best production occurring within the rudist reef facies which has vertical and lateral heterogeneity. Regional groundwater flow directions in the Middle Trinity generally follow the regional dip of the strata which is to the southeast (Mace et al., 2000; Hunt, et al., 2009; Wierman et al., 2010). The Hammett Shale, an important regional confining unit, separates the Middle and Lower Trinity Aquifers (Fig. 2). The Lower Trinity Aquifer is composed of the Sligo and Hosston Formations and is increasingly becoming targeted for groundwater production in the Hill Country due to limits on the overlying aquifers. The Lower Trinity is beyond the scope of this paper and the reader is referred to Wierman et al., (2010) for more information.

Current numerical groundwater flow models of the Trinity Aquifer reflect a conceptual model of water-bearing units functioning as a leaky aquifer system (Muller, 1990; Jones et al., 2011). For this study area, recharge in the numerical model (Jones et al., 2011) was distributed over the surface as 4% of annual precipitation. Recharge to the Middle Trinity is modeled to occur as direct recharge where exposed, or percolation through the Upper Glen Rose. In this study area, the model considers streams and rivers (such as Onion Creek and the Blanco River) as drains from the aquifer rather than sources of recharge to the aquifer (Jones et al., 2011).

Little work has been done on the surface-water and groundwater interactions (recharge) along Onion Creek over the Trinity Aquifers that could inform the conceptual and numerical models. This was true for the Blanco River until the recent study of Smith et al. (2014) that demonstrated the Blanco River has complex surface-water and groundwater interactions with alternating gaining and losing reaches present during both high- and low-flow conditions. Gaining reaches are due to the presence of springs and spring-fed tributaries that increase flows in the streams, while losing reaches result, in part, from discrete recharge features (karst features) that drain water from the river into the aquifer. Some of that water comes back out as springflow, but some remains in the Middle Trinity.

Onion Creek may be hydrogeologically similar to the Blanco River providing recharge to the Middle Trinity Aquifer. Statements by Muller (1990) about the Dripping Springs Water Supply Corporation well field adjacent to Onion Creek support that hypothesis:

> "Onion Creek may serve as a source of recharge for the system at the WSC well field. Consequently, any pollution to Onion Creek could result in contamination to the Lower Glen Rose (Deep) aquifer which is hydrologically connected to the underlying water-bearing units of the Trinity Group aquifer currently providing ground water to the WSC well."

Upper Trinity Aquifer and Associated Springs

The Upper Trinity Aquifer is composed of the Upper Glen Rose Member and consists of stacked and interbedded dolomites, limestones, marls, and mudstones that produce a series of thin aquifers and aquitards (Muller, 1990). The Upper Trinity Aquifer is a complex and heterogeneous stacked and perched aquifer system with local to regional flow systems.

One of the important hydrologic functions of the Upper Trinity Aquifer is to provide baseflows to the streams of the Hill Country, such as Onion Creek. The Upper Trinity section in the study area is characterized by numerous small seeps and springs. Many of the springs are reported as perennial (Ashworth, 1983). The baseflows from this aquifer have long been recognized as an important source of water for ecological and recreational needs in the Hill Country, and as a source of recharge to the downstream Edwards Aquifer (Barker et al., 1994). Indeed, the area of outcropping Upper Trinity units in the study area is concurrent with what the TCEQ designates as the "Contributing Zone of the Edwards Aquifer" (TCEQ, 2008).

The Upper Trinity Aquifer is not considered a significant regional aquifer in the Hill Country, or the Onion Creek watershed. The Upper Trinity typically has low yield and generally poor water quality (Ashworth, 1983). Wells are typically completed today in the Middle Trinity Aquifer and to a lesser extent, the Lower Trinity Aquifer. Historically the Upper Trinity was an important aquifer and water supply for the ranching communities throughout the Hill Country. Private homes and ranches line the wooded banks of Onion Creek, and the city of Dripping Springs derives its name from springs emanating from an Upper Glen Rose outcrop. The shallow depth to groundwater allowed for the early development of the City of Dripping Springs. However, in the past 10 years, or more, there have been hundreds of wells drilled in northern Hays County with few, if any, wells completed solely within the Upper Glen Rose (personal communication, Alex Broun).

Historically there have been several localized areas of low-volume residential groundwater production from the Upper Trinity, such as the area around Dripping Springs. Depth to water in the Dripping Springs area can range from less than one foot to 60 ft. The shallow water producing zones of the Upper Glen Rose are Units 4 and 5, with these zones being perched on top of Unit 3 (Muller, 1990). Springs have been observed to originate at the interface of Zones 3 and 4, such as the Dripping Springs and Blue Creek Spring.

Due to lack of a sufficient number of wells with consistent well completions in the Upper Glen Rose, which has localized areas of perched groundwater, it is difficult to determine groundwater flow directions on a regional basis. Shallow groundwater flow and subsequent discharge occurs in seeps in topographic lows and in streams and their tributaries. Muller (1990) indicated groundwater flow in the upper, shallow units to be generally southwesterly towards Onion Creek within the City of Dripping Springs, although there is a northerly component of flow north of Highway 290.

Geochemistry

Water geochemistry was reviewed in order to help characterize surface-groundwater interactions. Surface-water chemistry of Onion Creek shows low concentrations of nutrients typical of Hill Country creeks (Mabe, 2007). Nitrate-nitrogen concentrations measured downstream of RR12 in 2014 to 2015 averaged 0.087 mg/L (detection limit of 0.008 mg/L). However, gradual increases in nutrient concentrations are evident and likely due to population growth. Mahler et al. (2011) report concentrations of nitrate that have increased six to ten times from 1990 to 2008 compared to the 2008 to 2010 time period in a study that included two sites on Onion Creek. They attribute the change to an increase in the number of septic tanks and land application of treated wastewater based on isotopic compositions. Gilroy and Richter (2011) show statistically significant spatial increases in nitrate and sulfate from upstream creek reaches to the USGS gauge at Farm to Market 150 (FM 150) and a significant temporal increase in chloride at the FM 150 gauge. The Texas Commission on Environmental Quality (TCEQ, 2014) has added Onion Creek to its 303(d) list as impaired for sulfate.

METHODS AND DATA SOURCES

Flow monitoring sites were selected based on stream channel conditions and accessibility. Sites were identified according to characteristics described in Turnipseed and Sauer (2010). Ideal characteristics include sites with relatively straight channels with uniform flow free of obstructions creating eddies, slack water, and turbulence. Deep-water sites with low velocities were also avoided.

A total of 69 sites in the study area were directly measured or qualitatively described during the study period January through December 2015. Field work and flow measurements began January 2015 as part of the reconnaissance and selection of sites prior to the July synoptic event. Most sites were measured multiple times prior to the July and November synoptic events. Thirty-five of the sites were located directly on the main Onion Creek channel with the remainder situated along tributaries. Two springs in smaller tributaries were also measured directly. Qualitative observations of flow were limited to the very low flows primarily in tributaries or where no flow existed in the main channel of Onion Creek (Table 1). All the measured and qualitative flow data and metadata were compiled into a geodatabase. Original FlowTracker files are archived at the Barton Springs/Edwards Aquifer Conservation District (BSEACD). Queries of the database were used to create maps (ArcMap™) and hydrographs (Goldenware Grapher™) used in this report.

A total of a 196 quantitative and qualitative measurements were made during the study period. Of these, 139 measurements were made using the flow measurement techniques described herein. The quantitative wading measurements of streamflow were made using acoustic Doppler velocimeters (ADV) (Fig. 4). The Hays Trinity Groundwater Conservation District (HTGCD), BSEACD, and the City of Austin (CoA) used a hand-held FlowTracker ADV manufactured by SonTek/YSI. The FlowTracker ADV is mounted on a standard wading rod and measures currents in 2D and provides discrete data on depth and velocity. Techniques and standards for making discharge measurements at streamflow gaging stations are described in Turnipseed and Sauer (2010) and Nolan et al. (2007). Data collected for this project generally followed the standards and protocols cited above. For example, the FlowTracker was used to collect data at each station using the “0.6 method” for water less than 1.5 ft deep, or the “0.2/0.8 method” for 1.5 ft and deeper water. Both FlowTracker units used in this study were calibrated by the U.S. Geological Survey (USGS) Hydrologic Instrumentation Facility within 6 months of field use.

Uncertainty estimates of each discharge measurement are calculated by FlowTracker and are stored in each electronic file and are reported in Table 1. The two methods for calculating uncertainty in the FlowTracker are the International Organization for Standardization (ISO, 2003) and the Statistical (also called “Stats”; Sauer and Meyer, 1992) methods. The ISO is a published international method and is widely used to estimate an average uncertainty. Using the ISO method for data from the main channel of Onion Creek (n=45) the average uncertainty is about 3.7% (range 2.1-8.3%). The Statistical Method was developed by the U.S. Geological

Survey and is the preferred method to estimate uncertainty according to the manufacturer of the FlowTracker (Huhta and Sloat, 2007). The Stats method estimated an average uncertainty for the main channel of Onion Creek (n=45) of about 7.3% (range 1.7-30.4%). The high 30.4 value was over the Edwards Recharge zone and could be omitted as an outlier and thus error is reduced to an average of 6.7%. Many agencies rate data as "good" if the uncertainty is within 5% and "fair" if the uncertainty is within 8% (Huhta and Sloat, 2007). Levels of uncertainty are higher for data from smaller tributary channels and also for low-flow conditions, when compared to uncertainty within larger channels and higher flow conditions.

Continuous stream flow values were obtained from the USGS site at the Driftwood station (site 08158700; USGS, 2016). For this study, a new gaging site was established below the Ranch Road 12 Bridge at Onion Creek. An absolute pressure transducer (In-Situ Rugged Troll 100) was attached to the bridge pier in the stream during the period of study. The probe is rated for 15 psi and recorded gage height every 10 minutes. A rating curve for flow was not developed for this site.

Continuous water-level data were obtained online from the Texas Water Development Board's automated water-level database (TWDB, 2016a) for the Hanks well (State well number 5755607). Data for the DSWSC#2 (5756703) were obtained from the Hays Trinity Groundwater Conservation District (unpub. data). Both wells are completed in the Middle Trinity and are very close (<300 ft) to Onion Creek. All four of the DSWSC wells (Nos. 1-4) are in relative close proximity and completed in the Middle Trinity Aquifer. Geophysical log information for the cross section was obtained from DSWSC #1 (5756702). DSWSC #1 was originally completed in the Lower Trinity, but was recompleted in 2014 as a Middle Trinity well. The DSWSC #1 well has a continuous water-level recorder maintained by the TWDB.

Well completion information from DSWSC and the TWDB was reviewed for DSWSC wells 1-4. Wells 1, 3 and 4 appear to be cased and grouted with cement from the ground surface down to the Cow Creek. Information available for the completion of DSWSC #2 is inconsistent. Further investigation is needed to confirm the completion for DSWSC #2. A fifth well is located near well DSWSC #3. The well is capped and may be a previous test well. To date, no construction information on this well has been found.

Water-chemistry data in the Onion Creek watershed are available from TWDB for wells and springs (TWDB, 2016b), the U.S. Geological Survey (USGS, 2016) for surface water from a gauge at FM 150, and the City of Austin for surface water (CoA, unpub. data). Geochemical data were obtained from DSWSC #2 (5756703) and #3 (5756704) (TWDB, 2016b).

Detailed geologic and hydrogeologic data were incorporated into the evaluation to understand the hydrogeologic significance of the data (HTGCD and BSEACD, unpub. data). Geologic data include measured sections (Fig. 1) and outcrop descriptions combined with published literature (Fig. 3).

RESULTS

Flow measurements and site information from the main channel of Onion Creek from the two synoptic events in July and November 2015 are presented in Table 1. Additional measurements were taken in the tributaries and main channel during these two synoptic events (Figs. 5 and 6). Results show a complex interaction of surface and groundwater with losing and gaining reaches of creeks and tributaries to Onion Creek. Generalized reaches of Onion Creek and South Onion Creek, that show net losses in flow for both synoptic events, are indicated in map view on Figures 5 and 6. Additional confirmation measurements along the losing stretch were made in December 2015 (Table 1; Fig. 7). Figure 7 shows flow in the main channel versus distance from the headwaters of Onion Creek and illustrates the gains and losses of the main channel, with net losing reaches indicated. Results, summarized in Figure 8, indicate four distinct hydrogeologic reaches during both low- and high-flow conditions in the main channel of Onion Creek. Those reaches are described here as:

A. Upper Glen Rose net gaining reach #1: gains of 11 and 27 cfs from mile 0 (headwaters) to mile 13.
B. Upper Glen Rose net losing reach: net losses of 3 cfs with up to 17 cfs locally from mile 13 to mile 20. Figure 9 is a photograph of a karst feature within this reach. A flow of 0 cfs was recorded between synoptic events (September 2015), while reaches above and below had flow. Aerial photographs (Google Earth® dates 4/29/2006, 10/30/2008, and 3/23/2013) confirmed this as a dry (losing) reach of Onion Creek. Similarly, South Onion Creek from its confluence with Onion Creek, to about 3 miles upstream, is a losing reach with a loss of about 3 cfs.
C. Upper Glen Rose net gaining reach #2: gains of 21 and 84 cfs from mile 20 to mile 37.
D. Edwards Group net losing reach: losses of 29 and 108 cfs from mile 37 to mile 46 where water recharges through numerous karst features. This reach corresponds to the Edwards Aquifer Recharge Zone.

DISCUSSION

Surface-Water and Groundwater Exchange

It is well known that Upper Trinity seeps and springs provide baseflows and account for the gaining reaches to Onion Creek and its tributaries. It has been long established that the streams provide recharge to the Edwards Aquifer (Hill and Vaughn, 1898; Slade et al., 1986). However, this study, for the first time, documents reaches of Onion and South Onion Creeks that lose flow (Figs. 5-9) to the Upper and Middle Trinity Aquifers. The following lines of evidence suggest that the losing reaches of Onion and South Onion Creeks are one source of recharge to the Middle Trinity Aquifer.

First, under relatively high- and low-flow conditions the creek consistently loses flow in the same areas. The occurrence of karst features in these reaches supports that this is a losing creek (Fig. 9).

Second, potentiometric surfaces (Hunt et al., 2009) and Middle Trinity monitor wells along the creek support a downward flow potential under wet and dry hydrologic conditions from Onion Creek to the Middle Trinity Aquifer. Depth to water in the Middle Trinity Aquifer from the ground surface can range from 100 to 200 ft at the Hanks well and 25 to 150 ft at DSWSC #2 (Figs. 10 and 11).

Third, recharge in the losing reaches elevates groundwater levels. The hydrograph for DSWSC #2 (5756703), which is primarily Cow Creek production (Middle Trinity), shows a rapid response to high creek flows during heavy rainfall that may be from recharge of the surrounding surface runoff (Fig. 10). Additionally, high flow in the creek appears to result in increased recharge, and higher heads in the vicinity of the losing reaches of both Onion and South Onion Creeks. Figures 10 and 11 illustrate that higher elevations in water levels can occur in DSWSC#2 than the upgradient Hanks well (3.8 miles northwest) during periods of high creek flow.

Fourth, a relatively thin and fractured Upper Glen Rose may enhance recharge to the Middle Trinity Aquifer in this area. Based on the structural cross section in Figure 3 and other publications (Muller, 1990; Wierman, et al. 2010), there is only a very thin remnant of the Upper Glen Rose section in this area of about 20 ft.

Finally, isotope and ion geochemistry suggest recharge is occurring. Chemical analysis of groundwater samples from DSWSC wells #2 and #3 indicated an ion chemistry similar to surface water (Table 2; Figure 12). Isotopes of modern carbon resulted in 102% and 73% (TWDB, 2016b), respectively, indicating some portion of modern recharge from surface water. Relatively high levels of tritium (1.8 TU) in DSWSC#3 also suggest recent water (Table 2). Geochemistry and isotope samples were taken during the study period of June and July 2015.

While the evidence above indicates surface water recharging the Middle Trinity, and supported in part by data from the DSWSC wells, the magnitude of the surface recharge to the Middle Trinity Aquifer is unknown. For example, a logical conclusion from the data is that water produced from the Middle Trinity DSWSC wells is a mixture of both groundwater moving downgradient from the west and more localized recharge that varies in quantity as hydrologic conditions change.

Some of the recharging surface water along Onion Creek may resurface at springs downgradient of the losing creek reaches, while some of the water may also remain within the Upper Trinity and move down-gradient in the aquifer. In addition, geological surface mapping (Collins, 2002b) and field identification shows remnant outcrop of Quaternary terrace deposits (gravels) all along Onion Creek and its tributaries. Surface-water loss to these porous rocks may account for minor amounts of the measured flow loss along the reaches and subsequent gain as the creek cuts into these shallow deposits. However, this would not account for the additional evidence outlined above, indicating recharge to the Middle Trinity Aquifer from Onion Creek.

Geochemistry

Analytical results for ion chemistry were separated on the basis of Upper and Middle Trinity Aquifers and surface water. Ion chemistry shows that springs discharging from the Upper and

Middle Trinity Aquifers are similar to surface water compositions and classified as calcium/bicarbonate-type waters (Fig. 12). This supports the conceptual model that springflows provide stream baseflows. However, groundwater from Upper and Middle Trinity wells have average concentrations that are magnesium/sulfate-type waters. Individually, wells from both the Upper and Middle Trinity Aquifers tend to be predominantly calcium rich with some enrichment in magnesium, but have a wide range in variation between bicarbonate and sulfate enrichment. The differences in individual wells are likely related to the variable depths and geologic units in which the wells are completed and the amount of gypsum in the formation. Specifically the geochemistry from the DSWSC #2 and #3 (Table 2; Figure 12) plots as calcium/bicarbonate water for some samples, similar to springs and surface water, suggesting a fresh-water signature. The variation from magnesium/sulfate-type waters to calcium/bicarbonate-type waters in each of these wells over time likely reflects local dynamic recharge from Onion Creek with relatively rapid transmission along karst features.

Future Studies

These studies provide strong evidence that water flowing in Onion creek is recharging the Upper and Middle Trinity Aquifers along certain reaches of the streams. The greatest uncertainty of these studies is how much, how quickly, and under what conditions does recharge occur. In addition, other reaches of the creek that have a net gain in flow (reaches A and C) may still recharge the Upper and Middle Trinity Aquifers. However, more data would be needed to address that question.

To address these uncertainties the authors and various agencies and individuals are continuing to collect hydrogeologic data and plan additional studies. Future efforts or studies could involve: injecting dye into karst features (or losing creek reaches) and monitoring wells and downstream springs to establish the fate of creek-flow losses; more detailed synoptic flow studies and the establishment of additional stream gages with continuous recorders; additional surface and groundwater samples for chemical analysis, and dedicated monitor wells with discrete sampling zones.

CONCLUSIONS

Results of this study indicate complex surface and groundwater interactions in the Onion Creek watershed. For the first time, flow losses are documented to occur along a creek reach underlain by the Upper Glen Rose that has implications for recharge to the Middle Trinity Aquifer. Flow losses combined with other hydrogeologic and geochemical data suggest Onion Creek provides recharge to the Upper and Middle Trinity Aquifer in those reaches. A better understanding of the surface water and groundwater interactions along the creek is important for groundwater and surface water management in an area undergoing significant population growth. These results will also guide future studies and influence changes to the conceptual model of the Trinity Aquifers.

ACKNOWLEDGMENTS

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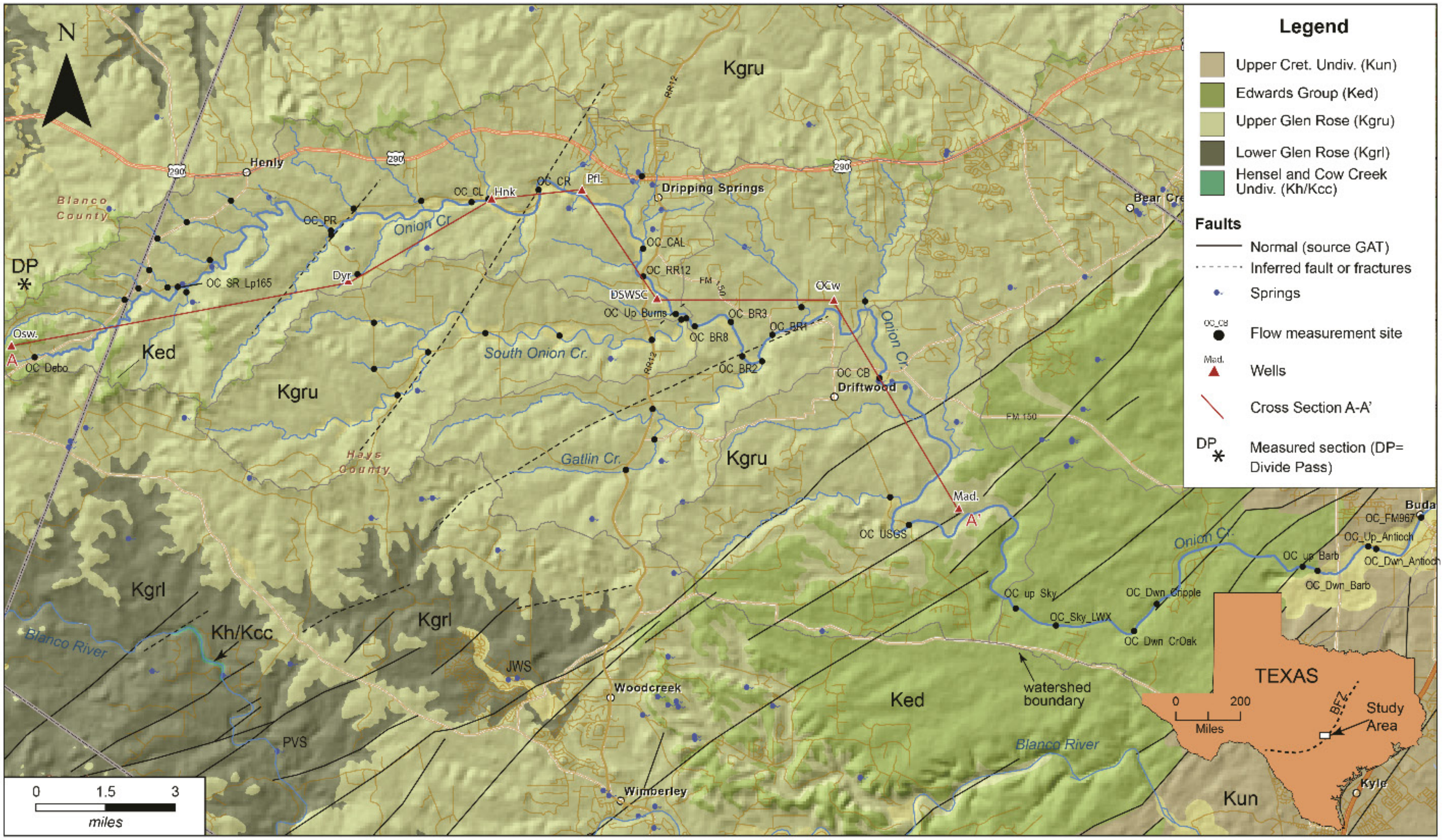


Figure 1. Location map of study area. Geologic base map from the Geologic Atlas of Texas (GAT). All sites are indicated (n=69), but only the main channel of Onion Creek results (n=22) are labeled and in Table 1.

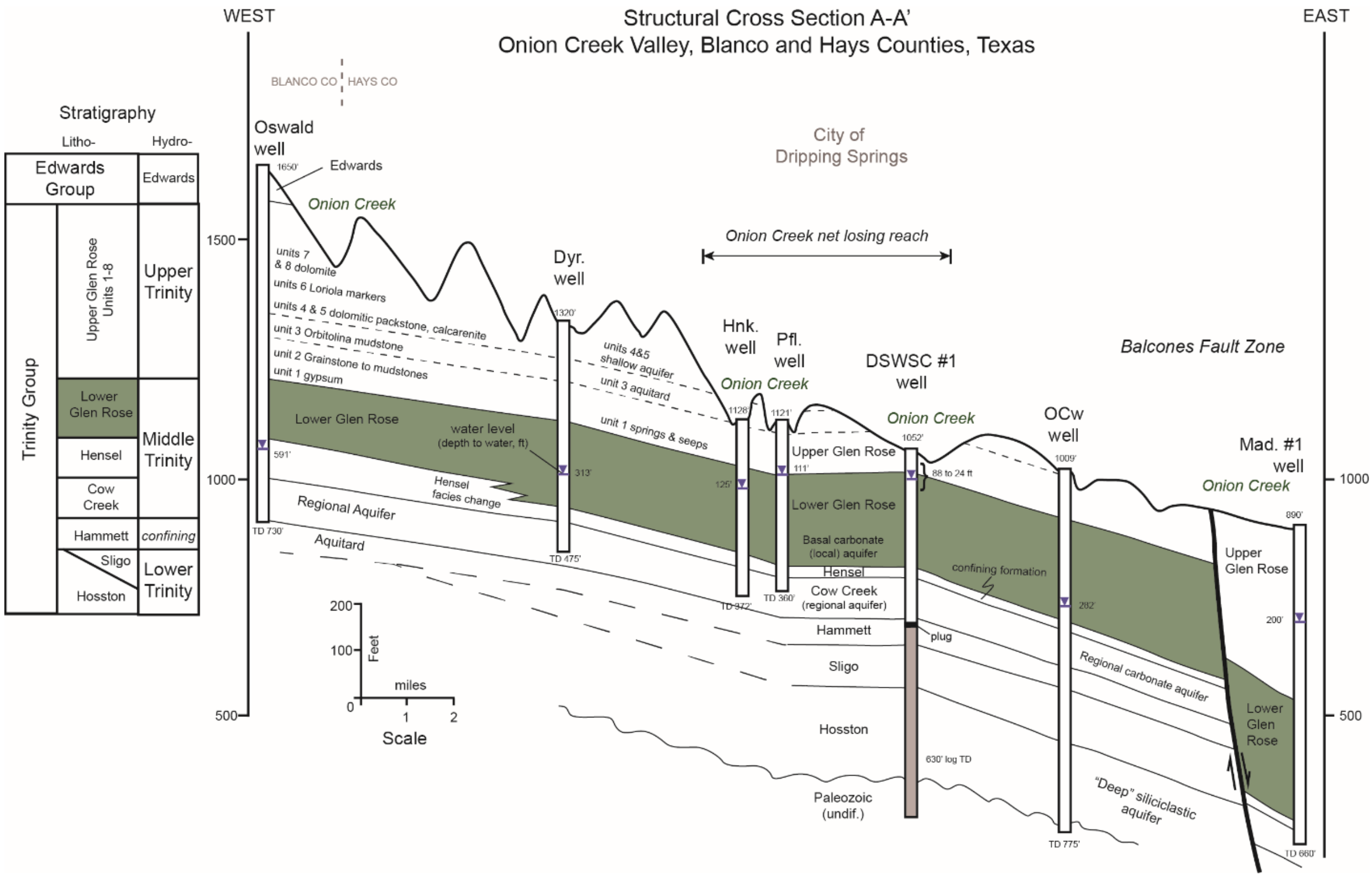


Figure 2. Structural cross section of study area and regional litho- and hydrostratigraphy. Line of section indicated on Figure 1. Note the thin Upper Glen Rose coinciding with the losing reach of Onion Creek in the area of the DSWSC well.

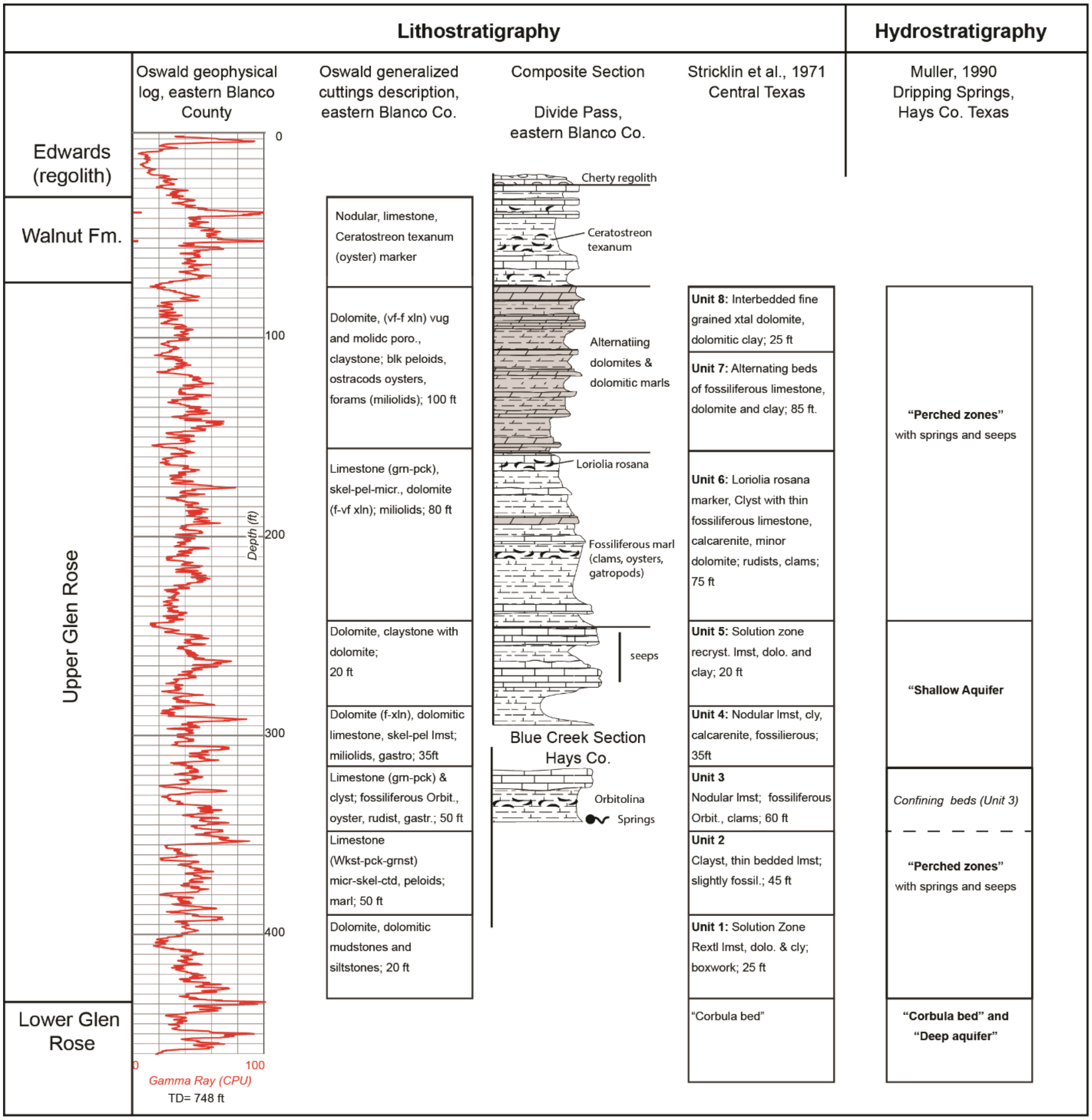


Figure 3. Study area lithostratigraphy and hydrostratigraphy focusing on the Upper Glen Rose member. Regional stratigraphy shown in Figure 2.

Figure 4. Photo of wading flow measurement using the FlowTracker instrument at the Onion Creek at FM 150 (USGS site). Photo taken 1/6/15.

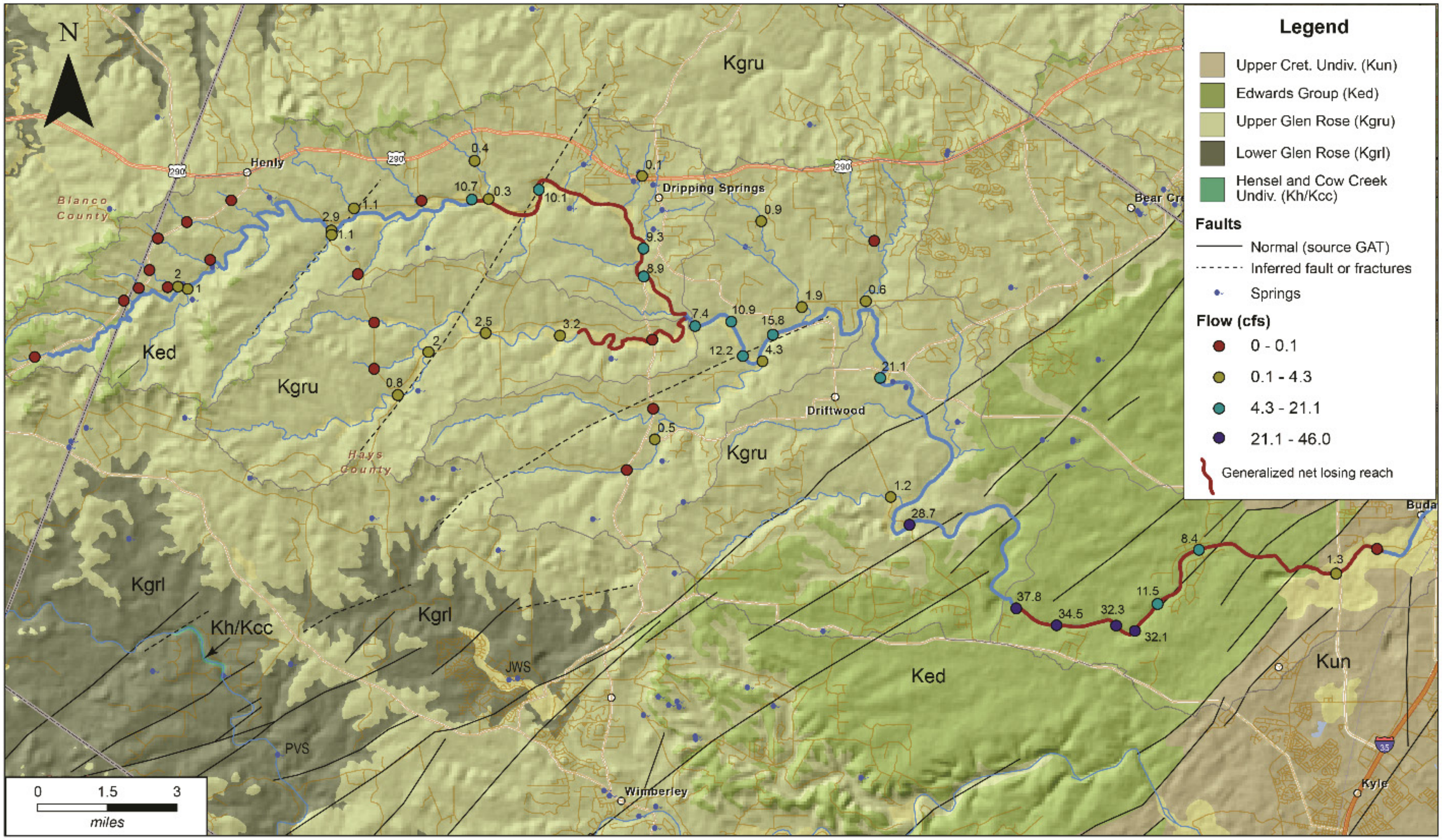


Figure 5. All flow results from the July 2015 synoptic event. The synoptic event included 21 sites in the main channel of Onion Creek and 20 sites in tributaries.

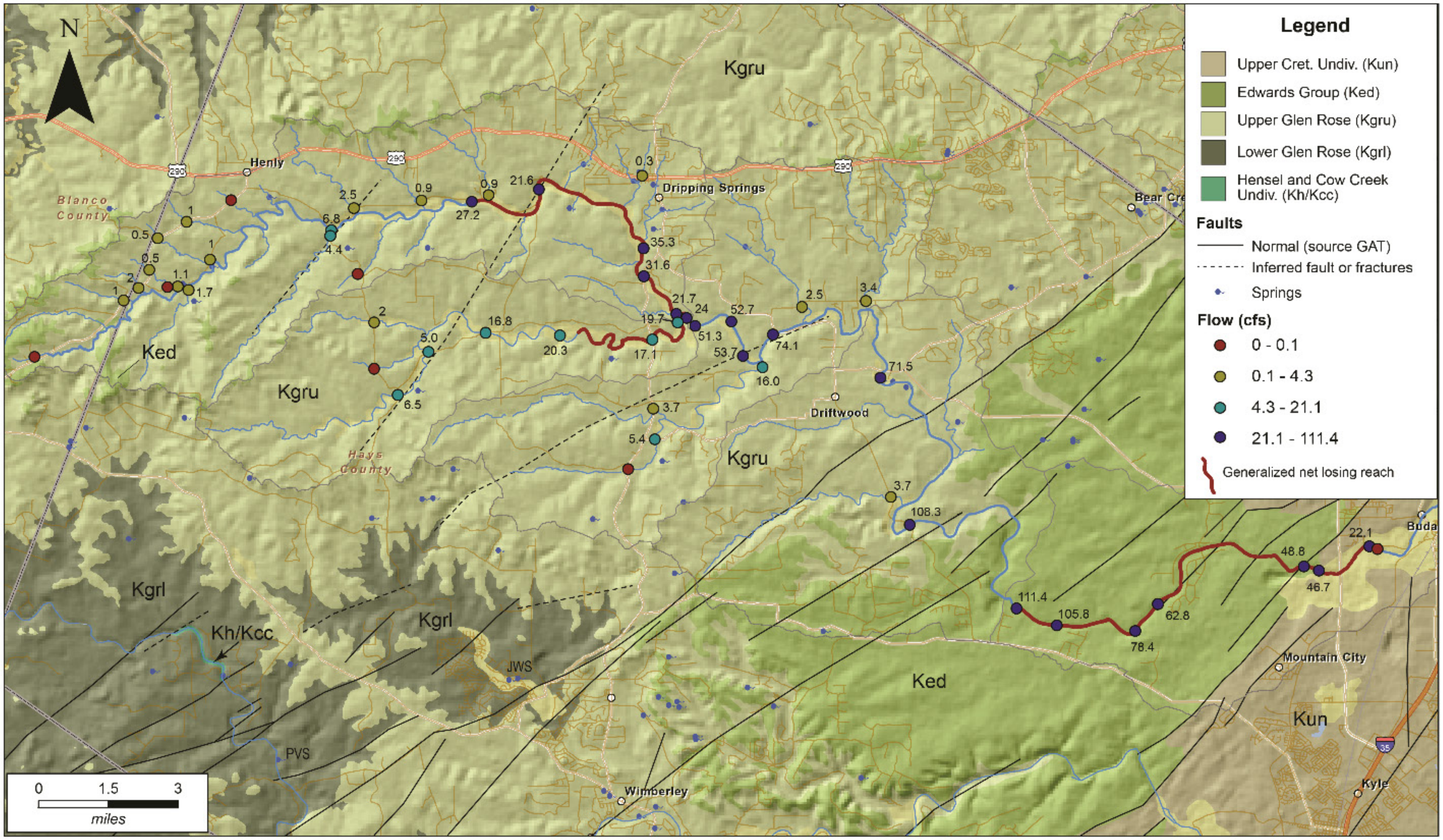
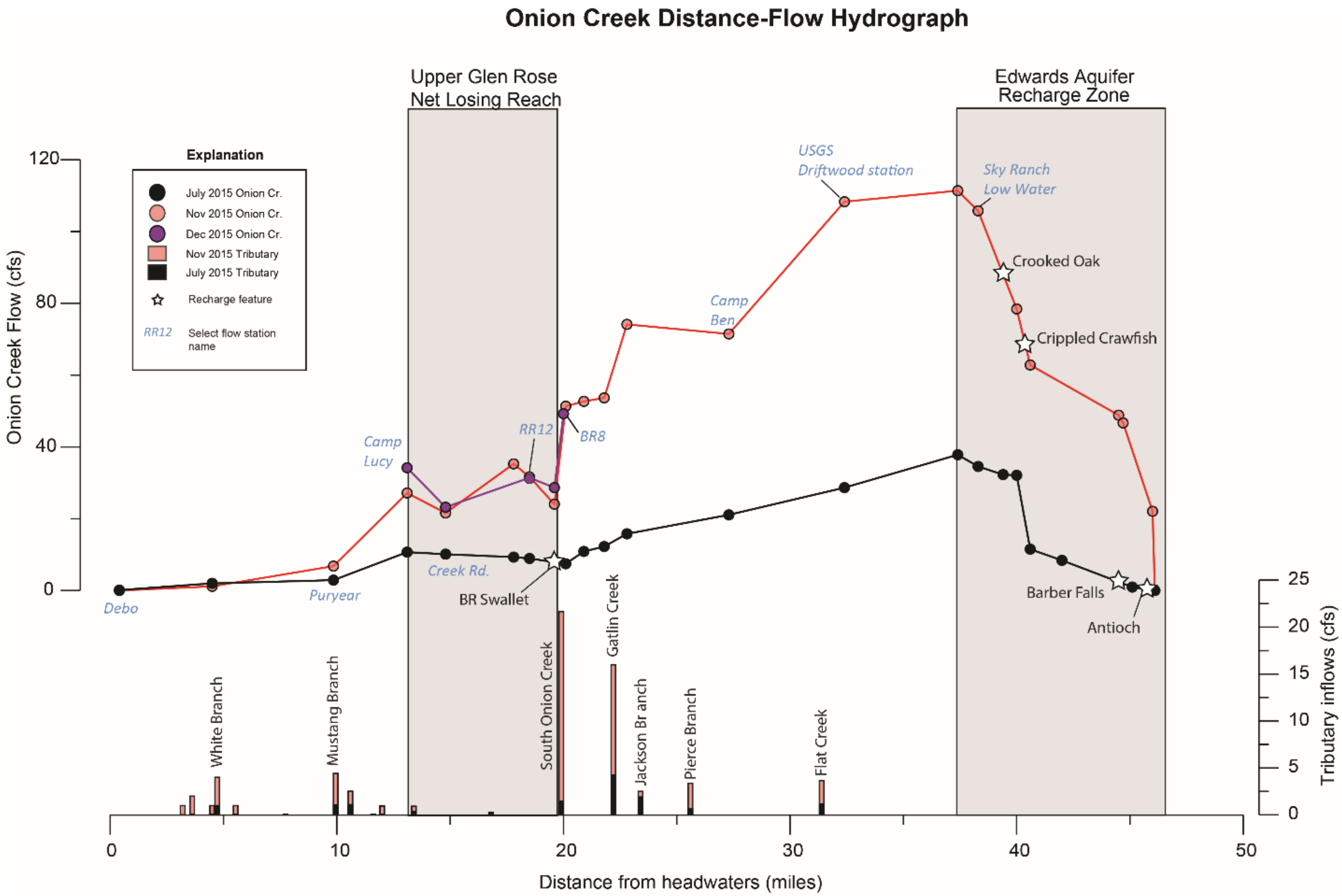


Figure 6. All flow results from the November 2015 synoptic event. The synoptic event included 22 sites in the main channel of Onion Creek and 20 sites in tributaries.



Onion Creek Distance-Flow Hydrograph
Upper Glen Rose
Net Losing Reach
Edwards Aquifer
Recharge Zone
Explanation
July 2015 Onion Cr.
Nov 2015 Onion Cr.
Dec 2015 Onion Cr.
Nov 2015 Tributary
July 2015 Tributary
Recharge feature
RR12
Select flow station name
Onion Creek Flow (cfs)
120
80
40
0
USGS
Driftwood station
Sky Ranch
Low Water
Crooked Oak
Camp
Ben
Crippled Crawfish
RR12
BR8
Camp
Lucy
Creek Rd.
BR Swallet
Puryear
Debo
Barber Falls
Antioch
White Branch
Mustang Branch
South Onion Creek
Gatlin Creek
Jackson Br anch
Pierce Branch
Flat Creek
Tributary inflows (cfs)
25
20
15
10
5
0
0
10
20
30
40
50
Distance from headwaters (miles)

Figure 7. Flow in the main channel of Onion Creek plotted versus distance.

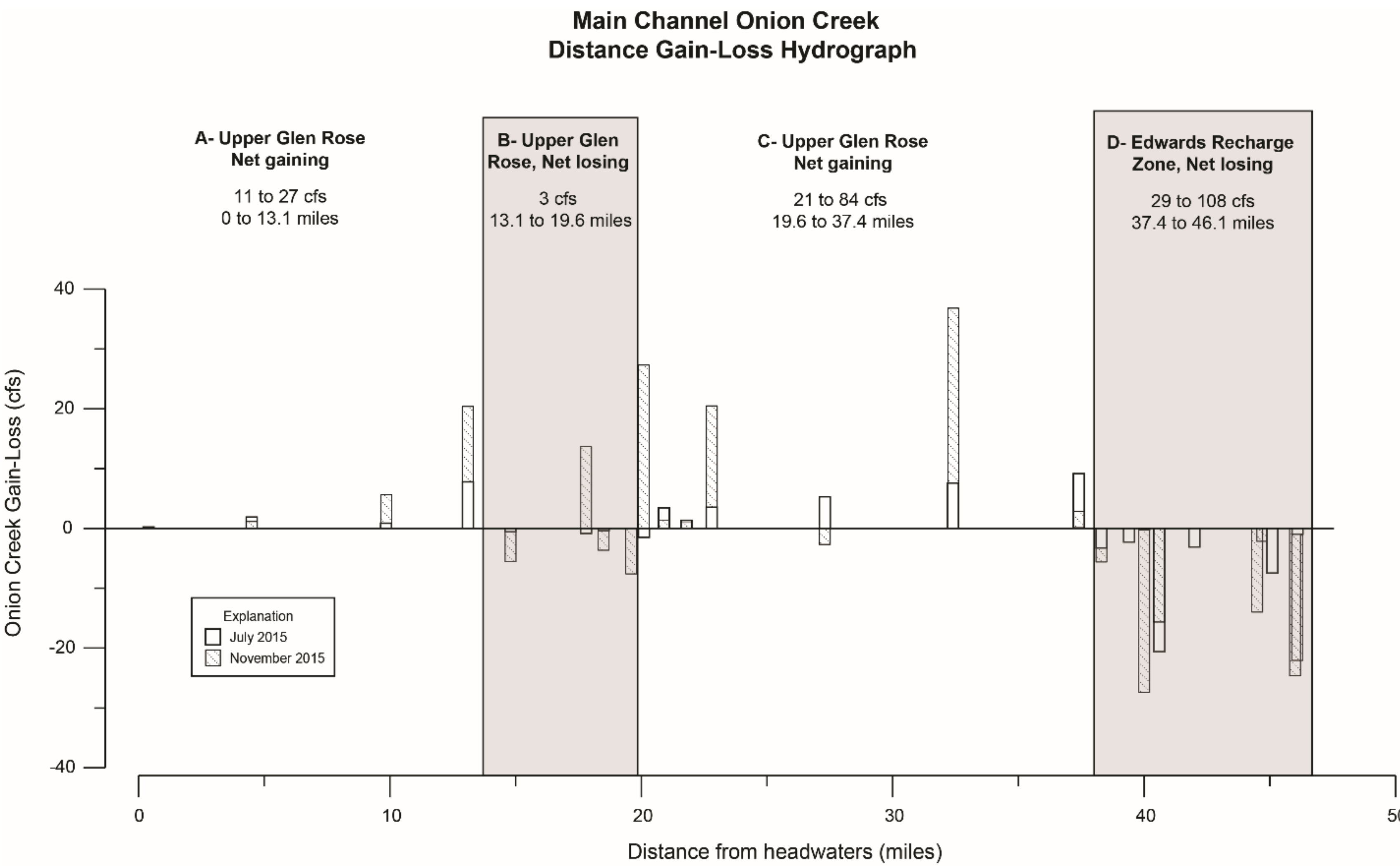


Figure 8. Flow gains and losses plotted versus distance. Data at each site represents the gain or loss from the preceding site immediately upstream in the main channel of Onion Creek.

Figure 9. Photograph of swallet (karstic sinking stream feature) within Onion Creek. The swallet is developed along fracture and water is whirlpooling into the rock at the tip of the hammer. Feature is within the identified losing reach of Onion Creek about 19.7 miles downstream from the headwaters. Photo taken 8/6/15.

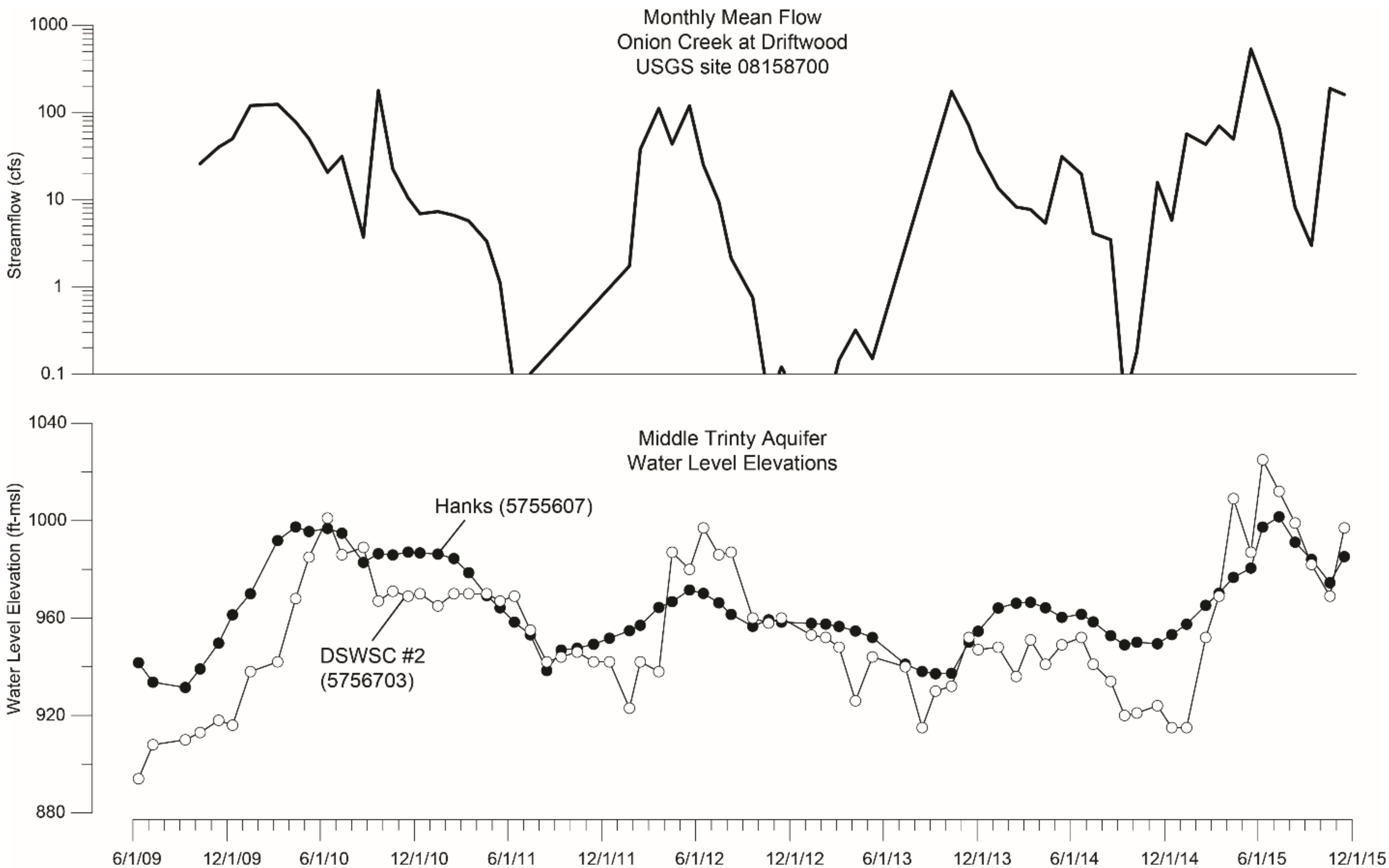


Figure 10. Hydrograph showing Onion Creek flows versus the Hanks well (5755607; TWDB, 2016a) and DSWSC #2 (5756703; HTGCD unpub. data), which are Middle Trinity Aquifer wells adjacent to Onion Creek. Note during wet periods, the DSWSC #2 well has a higher elevation than the upgradient Hanks well, which is located 3.8 miles to the northwest.

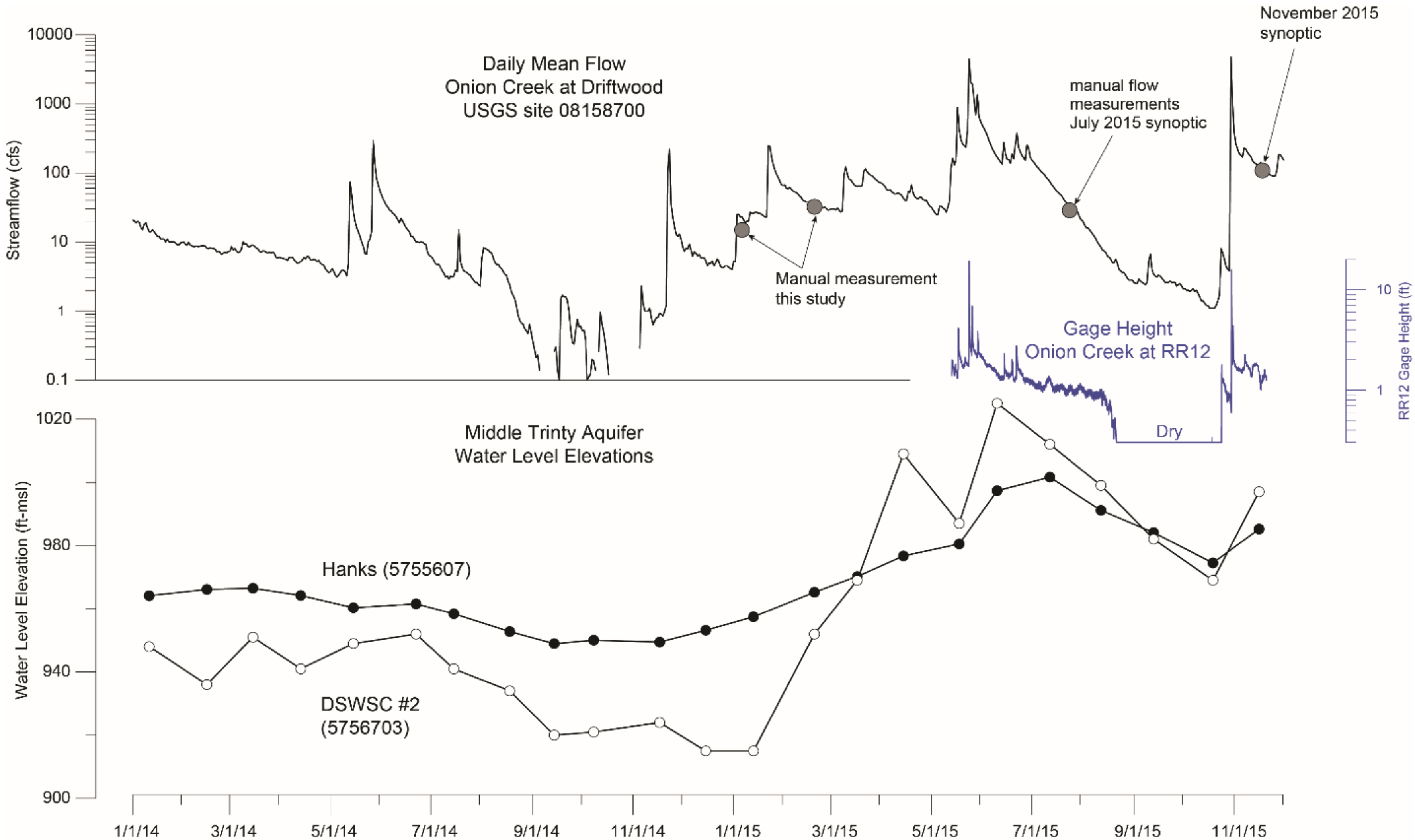


Figure 11. Hydrograph of Onion Creek flow (USGS, 2016) and Onion Creek at Ranch Road 12 gage height data with the Hanks well (5755607; TWDB, 2016a) and DSWSC #2 (5756703 HTGCD unpub. data), which are Middle Trinity Aquifer wells. Note that during each of the synoptic events, which occurred during a relatively wet year, the heads in the DSWSC#2 were higher than the upgradient Hanks well. Also note the general agreement of manual measurements taken during this study compared to the USGS Gaging station.

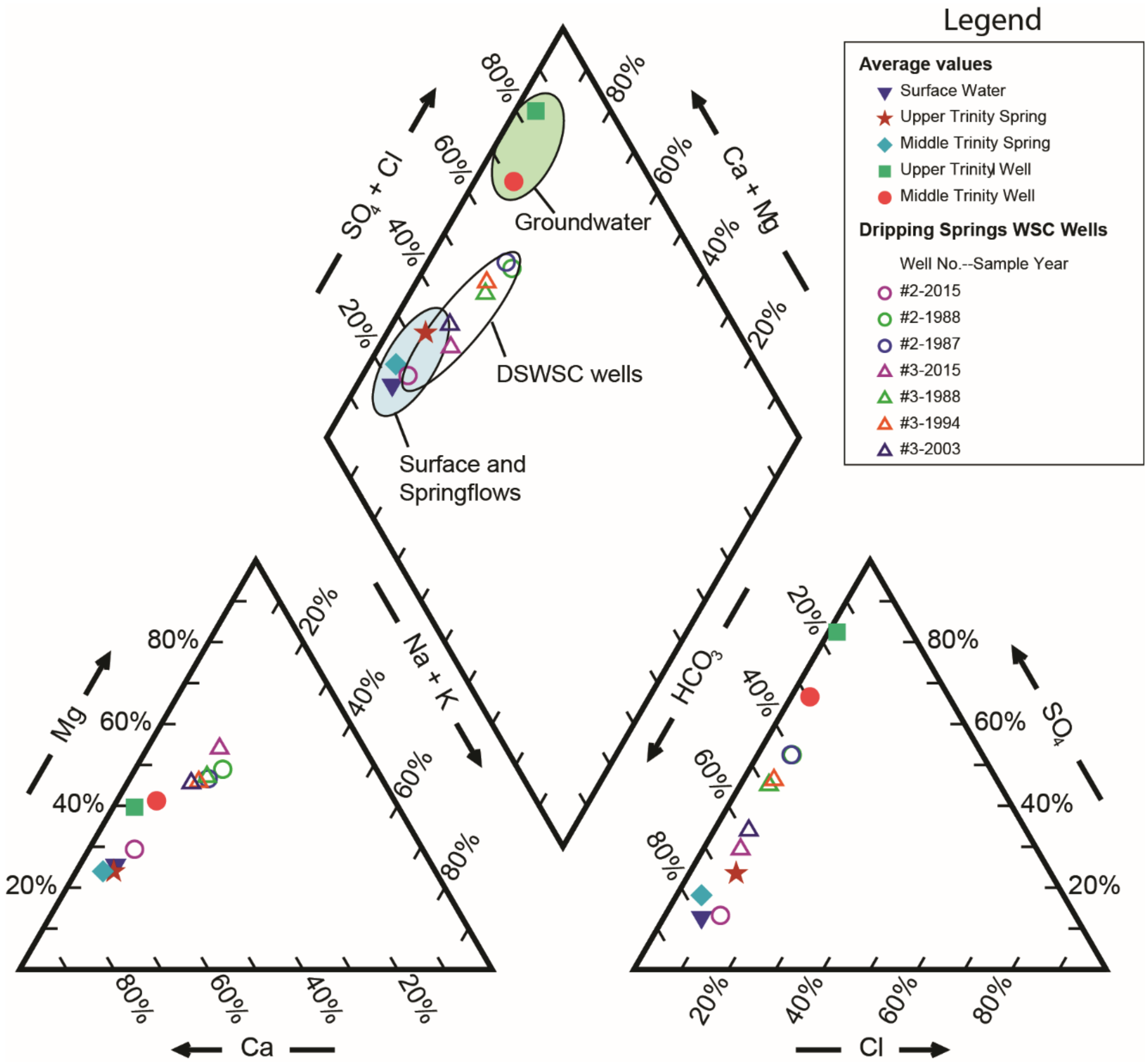


Figure 12. Piper diagram showing groundwater and surface-water geochemistry. All values are average except for the indicated DSWSC #2 and #3 wells, which represent single sampling events (Table 2). Note the variability of chemistry from the DSWSC wells with some samples overlapping surface-water chemistry. Samples taken in 2015 had similar chemistry as surface water in Onion Creek, and they contained high percent modern carbon and tritium, indicating a very young age of the water.

Table 1. Summary of flow results from main channel of Onion Creek for July and November 2015 synoptic events. Flag: o= qualitative flow observation; and m=quantitative flow measurement.

Synoptic	Date	Site ID	Distance (miles)	Total Discharge (cfs)	Gain/loss (cfs)*	Site Name	Ddlat	Ddlong	flag	ISO %	Stats %
Jul-15	7/23/2015	OC_Debo	0.4	0.1		Onion Creek at Debo rd	30.135695	-98.281188	o		
	7/23/2015	OC_SR_Lp165	4.5	2.0	1.9	SR Loop 165	30.157570	-98.236524	o		
	7/23/2015	OC_PR	9.9	2.9	0.9	Onion Creek at Pursley Road	30.175170	-98.188690	m	4.5	2.2
	7/23/2015	OC_CL	13.1	10.7	7.8	Onion Creek at Camp Lucy	30.184740	-98.144780	m	4.7	17.9
	7/23/2015	OC_CR	14.8	10.1	-0.6	Onion Creek at Creek Road	30.187910	-98.123860	m	5.7	18.2
	7/23/2015	OC_CAL	17.8	9.3	-0.8	Caliterra	30.169530	-98.091338	m	6.2	5.1
	7/23/2015	OC_RR12	18.5	8.9	-0.4	Onion Creek at RR12	30.160780	-98.091240	m	3.2	4.3
	7/23/2015	OC_BR8	20.1	7.4	-1.5	BR Ranch 8	30.145278	-98.075195	m	3.7	14.0
	7/23/2015	OC_BR3	20.9	10.9	3.4	BR Ranch 3	30.146664	-98.063825	m	4.3	6.5
	7/23/2015	OC_BR2	21.8	12.2	1.4	BR Ranch 2	30.135936	-98.060247	m	3.5	6.4
	7/23/2015	OC_BR1	22.8	15.8	3.5	BR Ranch 1	30.142650	-98.050939	m	3.0	4.2
	7/23/2015	OC_CB	27.3	21.1	5.3	Onion Creek at Camp Ben	30.129160	-98.017420	m	3.8	3.6
	7/24/2015	OC_USGS	32.4	28.7	7.6	Onion Creek downstream USGS gauge	30.083336	-98.008231	m	4.1	4.8
	7/17/2015	OC_up_Sky	37.4	37.8	9.2	Upstream WQPL	30.057325	-97.974918	m	3.3	7.6
	7/17/2015	OC_Sky_LWX	38.3	34.6	-3.3	Low-water Crossing	30.051976	-97.962332	m	5.6	22.6
	7/17/2015	OC_Up_CrOak	39.4	32.3	-2.3	upstream of crooked oak	30.051906	-97.943807	m	2.8	6.5
	7/17/2015	OC_Dwn_CrOak	40.0	32.1	-0.2	Upstream Crippled Crawfish	30.050201	-97.937917	m	3.7	5.7
	7/17/2015	OC_Dwn_Cripple	40.6	11.5	-20.6	Downstream Crippled Crawfish	30.058688	-97.930834	m	3.2	14.2
	7/16/2015	OC_Ruby	42.0	8.4	-3.1	Ruby Ranch	30.075524	-97.917959	m	2.8	11.8
	7/16/2015	OC_FM1626	45.1	1.0	-7.4	FM 1626 and Downstream Barber	30.068084	-97.875153	m	8.3	30.4
	7/16/2015	OC_Dwn_Antioch	46.1	0.0	-1.0	Downstream Antioch	30.075834	-97.862412	o		
Nov-15	11/18/2015	OC_Debo	0.4	0.0	0.0	Onion Creek at Debo rd	30.135695	-98.281188	o		
	11/20/2015	OC_SR_Lp165	4.5	1.1	1.1	SR Loop 165	30.157570	-98.236524	m	5.0	11.9
	11/19/2015	OC_PR	9.9	6.8	5.6	Onion Creek at Pursley Road	30.175170	-98.188690	m	4.0	3.7
	11/19/2015	OC_CL	13.1	27.2	20.4	Onion Creek at Camp Lucy	30.184740	-98.144780	m	3.7	6.3
	11/19/2015	OC_CR	14.8	21.6	-5.6	Onion Creek at Creek Road	30.187910	-98.123860	m	3.9	3.7
	11/19/2015	OC_CAL	17.8	35.3	13.7	Caliterra	30.169530	-98.091338	m	5.7	10.1
	11/19/2015	OC_RR12	18.5	31.6	-3.6	Onion Creek at RR12	30.160780	-98.091240	m	3.2	12.7
	11/19/2015	OC_Up_BR	19.6	24.0	-7.6	Upstream BR	30.149065	-98.081042	m	4.0	6.5
	11/19/2015	OC_BR8	20.1	51.3	27.3	BR Ranch 8	30.145278	-98.075195	m	4.0	5.8
	11/19/2015	OC_BR3	20.9	52.7	1.3	BR Ranch 3	30.146664	-98.063825	m	2.4	2.4
	11/19/2015	OC_BR2	21.8	53.7	1.0	BR Ranch 2	30.135936	-98.060247	m	2.9	1.7
	11/19/2015	OC_BR1	22.8	74.1	20.5	BR Ranch 1	30.142650	-98.050939	m	3.7	3.2
	11/19/2015	OC_CB	27.3	71.5	-2.7	Onion Creek at Camp Ben	30.129160	-98.017420	m	3.1	2.6
	11/18/2015	OC_USGS	32.4	108.3	36.8	Onion Creek downstream USGS gauge	30.083336	-98.008231	m	2.6	2.3
	11/18/2015	OC_up_Sky	37.4	111.4	3.1	Upstream WQPL	30.057325	-97.974918	m	2.3	3.5
	11/18/2015	OC_Sky_LWX	38.3	105.8	-5.6	Low-water Crossing	30.051976	-97.962332	m	2.4	3.8

	11/18/2015	OC_Dwn_CrOak	40.0	78.4	-27.4	Upstream Crippled Crawfish	30.050201	-97.937917	m	2.1	3.0
	11/18/2015	OC_Dwn_Cripple	40.6	62.8	-15.6	Downstream Crippled Crawfish	30.058688	-97.930834	m	2.7	5.7
	11/18/2015	OC_up_Barb	44.5	48.8	-14.0	Upstream Barber Falls	30.070363	-97.885332	m	2.8	2.8
	11/18/2015	OC_Dwn_Barb	44.7	46.7	-2.2	Downstream Barber Falls	30.069022	-97.880701	m	3.5	3.4
	11/20/2015	OC_Up_Antioch	46.0	22.1	-24.6	Upstream Antioch	30.076632	-97.864871	m	4.8	5.7
	11/20/2015	OC_Dwn_Antioch	46.1	0.0	-22.1	Downstream Antioch	30.075834	-97.862412	o		
	12/7/2015	OC_CL	13.1	34.2		Onion Creek at Camp Lucy	30.184740	-98.144780	m	3.3	5.5
	12/7/2015	OC_CR	14.8	23.2	-11.0	Onion Creek at Creek Road	30.187910	-98.123860	m	2.7	5.3
	12/8/2015	OC_CAL	17.8	34	10.8	Caliterra	30.169530	-98.091338	m	3.3	5.5
	12/8/2015	OC_RR12	18.5	31.4	-2.6	Onion Creek at Creek Road	30.187910	-98.123860	m	2.7	3.6
	12/9/2015	OC_Up_BR	19.6	28.7	-2.7	Upstream BR	30.149065	-98.081042	m	3.1	7.0
	12/9/2015	OC_BR8	20.1	49.2	20.5	BR Ranch 8	30.145278	-98.075195	m	2.7	2.4
Dec-15	12/9/2015	OC_USGS	32.4	85.9	36.7	Onion Creek downstream USGS gauge	30.083336	-98.008231	m	2.3	3.2
***from preceeding station**									Max	8.3	30.4
									Min	2.1	1.7
									avg	3.7	7.3
									n	45	45

Table 2. Summary of geochemical data used in Figure 12. Source of data includes USGS (2016), TWDB (2016b), and CoA (unpub. data).

Parameter	Units	Avg. Surface Water RR12	Avg. Surface Water USGS FM 150	Avg. Upper Trinity Spring	Avg. Middle Trinity Springs	Avg. Upper Trinity Wells	Avg. Middle Trinity Wells	DSWSC #2 (5756703)	DSWSC #2 (5756703)	DSWSC #2 (5756703)	DSWSC #2 (5756703)	DSWSC #3 (5756704)	DSWSC #3 (5756704)	DSWSC #3 (5756704)	DSWSC #3 (5756704)	DSWSC #3 (5756704)
Date								6/21/2016	7/20/2015	6/27/1988	7/28/1987	6/21/2016	6/1/2015	8/6/2003	6/28/1994	6/27/1988
Calcium	mg/L	76.8	71.0	118.9	93.8	342.3	182.4		71.0	106.0	114.0		60.4	76.6	97.0	95.0
Magnesium	mg/L	18.4	16.5	25.8	19.8	149.6	90.9		20.9	98	88		64.8	52.3	70	74
Sodium	mg/L	12.0	8.3	14.9	7.6	22.0	28.6		11.7	61.0	52.0		28.4	24.7	37.0	41.0
Potassium	mg/L	1.4	1.3	2.0	1.7	12.8	9.2		1.8	15.0	11.0		9.6	6.6	9.8	11.0
Bicarbonate	mg/L	NT	254.20	353.80	308.80	301.60	328.20		265	395	388		297	337	369	398
Sulfate	mg/L	40	33	101	59	1255	596		37.7	411	397		111	156	288	292
Chloride	mg/L	24.9	14.4	30.2	12.2	16.4	25.7		23.6	42.0	39.0		21.1	23.4	30.0	29.0
TDS	mg/L	NT	271.5	485.5	350.5	1970.5	1217.2		308	943	930		474	530	742	751
Alkalinity	mg/L	206	207	290	255	247	270		217	324	318		243	276	302	326
Fluoride	mg/L	0.2	0.2	0.3	0.2	1.9	1.6		0.25	2.7	2.6		1.2	1.79	2.14	2.3
NO2+NO3-N	mg/L	0.087	0.263**	7.15	6.1	1.1	1.4		0.04				0.02*	0.02*	0.04	0.04*
Spec Cond	uS/cm	521	488	692	562	2064	1451	489	557	1760	1705	686	692	874		1377
pMC	%	na	na	na	na	na	na		102	na	na		73	na	na	na
Tritium	TU	na	na	na	na	na	na		na	na	na		1.8	na	na	na
COUNT		13	103/161***	7	30	22	131									

***detection limit**
****Combined filtered and unfiltered samples**
***** 103 samples for ions and 161 for nitrate**
na= not applicable

Attachment D

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September 12, 2016

Mr. Eric Allmon, attorney
Ms. Sarah Faust, attorney
Mr. Stuart Henry, attorney
Via email: eallmon@lf-lawfirm.com; stuartnhenry@gmail.com; sarah.b.faust@gmail.com;

Subject: **Evaluation of the Miertschin/Wiland Implementation of QUAL-TX for the Proposed Dripping Springs Wastewater Effluent Discharge to Onion Creek**

Dear Mr. Allmon, Ms. Faust, and Mr. Henry:

I have reviewed a technical memorandum by James Miertschin and Bruce Wiland, sealed by James Miertschin on November 24, 2015. This memorandum documents their approach and key assumptions in implementing the QUAL-TX water quality model to simulate impacts of the proposed City of Dripping Springs wastewater effluent discharge on dissolved oxygen concentrations in Onion Creek.

The TCEQ Water Quality Assessment Team, *Methods for Analyzing Dissolved Oxygen in Freshwater Streams Using an Uncalibrated QUAL-TX Model,* reviewed and updated by M. Rudolph on June 20, 2012,[1] describes methods to ensure consistency in the implementation of uncalibrated QUAL-TX models in determining permit limits. This document incorporates relevant TCEQ and EPA Region 6 stipulations in the Memorandum of Agreement finalized April 4, 2001. I found several significant inconsistencies between Miertschin/Wiland QUAL-TX model assumptions described in their technical memorandum and applicable requirements for uncalibrated QUAL-TX models in the Methods document.

1. **Onion Creek Headwater Flows**. Miertschin/Wiland used a value of 0.3 cubic feet per second to represent Onion Creek headwaters critical low flow. They describe this value as based on streamflow measurements in Onion Creek in the vicinity of the

[1] Referred to in subsequent paragraphs as the Methods document.

proposed discharge during the summer of 2015, which they characterize as "exceptionally dry". The Methods document, however, states: "*If base flow information is not available to estimate the 7Q2, then a value of 0.1 ft3/s is usually assumed for perennial streams, and a value of 0.0 ft3/s is used for intermittent streams."* Onion Creek in the vicinity of the proposed discharge is characterized by TCEQ as perennial and therefore the recommended value would be 0.1 cubic feet per second. Furthermore, my examination of U.S. Geological Survey average daily Onion Creek flows near Driftwood in 2105 indicates a minimum of flow of 2.8 cubic feet per second, a maximum of flow of 485 cubic feet per second, an average of flow of 101 cubic feet per second, and a median of flow of 54 cubic feet per second during June, July, and August. None of the average daily flows during this period, as reported by the U.S. Geological Survey, were as low as the median flow of 1.2 cubic feet per second for this location.[2] Based on measurements at the U.S. Geological Survey Driftwood gage, therefore, Onion Creek flows during the period used as a basis for estimating headwater flows in the Miertschin/Wiland QUAL-TX model are ***higher*** than normal. Onion Creek headwaters flows assumed by Miertschin/Wiland are, furthermore, higher than the downstream critical flow and higher than the value recommended in the Methods document. They do not appear to represent critical flow conditions in Onion Creek headwaters.

2. **Sediment Oxygen Demand**. The Miertschin/Wiland document states that they implemented the QUAL-TX model with a sediment oxygen demand value of 0.1 grams per square meter per day. They justify this value based on a qualitative description of the existing lack of stream sediment. They do not consider

[2] Miertschin and Wiland, November 24, 2015.

accumulations of organic sediment in the stream and its corresponding oxygen demand that would result from the proposed wastewater effluent discharge. Furthermore, the Methods document describes agreements between TCEQ and EPA Region 6 regarding chemical kinetic rates for uncalibrated QUAL-TX models. These agreed-to kinetic parameters for uncalibrated QUAL-TX water quality models included a sediment oxygen demand of 0.35 grams per square meter per day (at 20 °C). The Miertschin/Wiland QUAL-TX model will under-predict sediment oxygen demand compared to the TCEQ/EPA agreement and therefore likely over-predict dissolved oxygen concentrations in the water.

3. **Chlorophyll-A**. Miertschin/Wiland document two runs of the QUAL-TX model to predict Onion Creek dissolved oxygen concentrations. In one run chlorophyll-a concentrations are assumed to be 2 μg/L in every reach. The other run assumes no chlorophyll-a. The Miertschin/Wiland memorandum, however, states that upstream of the Mt Gainor Road monitoring station, a mean chlorophyll-a concentration of 1.5 μg/L was determined, even though only one chlorophyll-a reading was higher than detection limits.

   Based on the Methods document, the TCEQ/EPA Region 6 Memorandum of Agreement requires chlorophyll-a to be 0.0 μg/L, unless site-specific data is readily available to set minimum values. Given both the agreement conditions and measurements below detection limits, chlorophyll-a concentrations greater than zero for reaches above Mt. Gainor Road monitoring station are inconsistent with the TCEQ/EPA Region 6 Memorandum of Agreement.

In summary, the Miertschin/Wiland technical memorandum documents parametric assumptions in their implementation of QUAL-TX that appear to be inconsistent with the requirements of the TCEQ/EPA Region 6 Memorandum of Agreement for uncalibrated QUAL-TX models. The Miertschin/Wiland QUAL-TX results for Onion Creek without chlorophyll-a predict dissolved oxygen concentrations as low as 4.87 mg/L. QUAL-TX results with parameters that were consistent with TCEQ/EPA Region 6 agreements for dissolved oxygen modeling for headwater flows, sediment oxygen demand, and chlorophyll-A concentrations would likely predict Onion Creek dissolved oxygen concentrations that would violate applicable stream standards.

If you have any questions about what I have written here, I am happy to answer them.

Sincerely,

STATE OF TEXAS
D. LAUREN ROSS
56647
LICENSED
PROFESSIONAL ENGINEER

Lauren Ross, Ph. D, P.E., President
Glenrose Engineering

12 September 2016